ASSESING THE POTENTIAL APPLICABILITY OF BIM IN THE CONSTRUCTION INDUSTRY OF ETHIOPIA: THE CASE OF DIRE DAWA PUBLIC CONSTRUCTION PROJECTS

BY

DIRES ENKU

ADVISOR: Dr. TEMESGEN WONDIMU

A Thesis submitted to the School of Graduate Studies, Addis Ababa Science & Technology University in partial fulfillment of requirement of the degree of

Master of Science

In

Civil Engineering

(Structural Engineering)

May 2018

ACKNOWLEGMENTS

I would like to thank my thesis supervisor Dr.TemesgenWondimu for his invaluable advice, tremendous support, guidance and engagement through the learning process. I would also like to thank the Ethiopian Road Authority and Addis Ababa Science and Technology University for providing me with a full scholarship for my studies. Lastly, I would like to thank my family and friends for their continuous support, encouragement and advice.

DECLARATION

This thesis entitled **"ASSESING THE POTENTIAL APPLICABILITY OF BIM IN THE CONSTRUCTION INDUSTRY OF ETHIOPIA: THE CASE OF DIRE DAWA PUBLIC CONSTRUCTION PROJECTS"** is my original work and it has not been submitted previously for any other degree. The relevant information that has been taken from any source is recognized by means of references.

Author: signature Date

DiresEnku ____________________ ________________

CERTIFICATION

This is to certify that the thesis prepared by **Dires Enku** entitled ***"Assessing the potential applicability of BIM in the construction industry of Ethiopia: the case of Dire Dawa public Construction projects"*** and submitted to Addis Ababa science and Technology Universityfor the award of the degree of Master of Sciencecomplies with the regulations of the University and meets the accepted standards with respect to originality and quality.The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any other degree.

Date of Defense: Sept 29, 2017

Principal Advisor

Dr. TemesgenWondimu______ ______

Signature Date

Members of the Examining board:

1. Dr. GirmayKahassay_______ ________
   External ExaminerSignature Date
2. Dr. MelakuSisay._______ ________
   Internal ExaminerSignature Date
3. Mr. AmanuelEshetu_______ ________
   Chairman Signature Date
4. Dr. MelakuSisay._______ ________
   ERA, PG programme coordinator Signature Date
5. Mr. Simon G/egziabher _______ ________
   Head, Civil Eng'g Department Signature Date
6. Dr. Brook Abate _______ ________

Dean, College of Architecture Signature Date
And Civil Engineering

ABSTRACT

Building Information Modeling (BIM) is a cutting edge technology that has addressed prominent challenges in the Architecture, Engineering and Construction (AEC) industries in most of the developed countries.BIM represents the development and use of computer-generated n-dimensional (n-D) models to simulate the planning, design, construction and operation of a facility. It helps architects, engineers, consultants, clients and constructors to visualize what is to be built in simulated environment and to identify potential design, construction or operational problems.

The public construction projects of Dire Dawa are suffering from several construction problems. This paper explores the common construction problems in Dire Dawapublic construction projects, identifies problems that BIM potentially couldsolve, andalso gauges the awareness level of construction professionals towards BIM.

A Qualitative research method was conducted for the purposes of this study. Interviews were used as data collection tools. A total of 14 participants with a range of 1-12 years construction and design work experience from Dire Dawa public construction firms were interviewed. The interviews are aimed to assess the common construction problems in Dire Dawa public construction projects, and also to gauge the awareness level of construction professionals towards BIM. Usingthe interview results thematic analysis of interview responses was done to identify construction problems BIM can solve and professionals' awareness level towards BIM.

A case study project on the design of a G+4 Apartment project, located in Dire Dawa is presented. BIM software (Revit) is used with integration of SAP 2000 for structural design. In the case study the some of the potential benefits BIM: visualization, coordination, interference checking, and collaboration between disciplines (Architectural and Structural) is shown.

The findings identified twenty one (21)construction problems that exist in Dire Dawa public projects. Eleven construction problems out of the twenty one are asserted to be solved by the use of BIM. Finally Awareness of Construction professionals towards BIM is found to be Low.

The paper recommended the need for increased awareness and utilization of BIM via the participation of relevant professional bodies; the integration of BIM into the Academic curriculum, conducting governmental sponsored Pilot projects, BIM training for construction firms by government .This

facilitates increase in knowledge of BIM towards solving common construction problems in Dire Dawa public projectsby tapping the potential benefits of BIM.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AfDB	African Development Bank
BIM	Building Information Modeling
CAD	Computer Aided Design
CIDB	Construction Industry Development Board (South Africa)
DD	Dire Dawa
EBCS	Ethiopian Building Code Standard
ERA	Ethiopian Road Authority
FM	Facilities Management
GDP	Gross Domestic Product
HVAC	heating, ventilation and air-conditioning
IFC	Industry Foundation Classes
KPI	Key Performance Indicator
MEP	mechanical, electrical and plumbing services
MoWR	Ministry of Water Resources
MoWUD	Ministry of Works and Urban Development
NBIMS	National Building Information Modeling Standards:
OM	Operation Manager
RSDP	Road Sector Development Programme
SAP	Structural Analysis program

1. INTRODUCTION

1.1 Background

Construction industry has significant contribution to the national economy of any country. At a general economy level, in the past few years, Ethiopia's economy has expanded well. According to African Development BankGroup's Country Strategy Paper (2011), from 2006-2010, the Ethiopian economy registered anaverage growth of 11%, putting it among the fastest growing economy in Africa. Parallel to thisstrong economic performance, construction works in Ethiopia has grown strongly, with 11%growth in Gross Value Added. However, despite the recent improved performances, Ethiopia's infrastructure is among thelowest even when compared to Sub-Saharan Africa. In this regard, for comparison purpose based on a 2010 data, the African Development Bank's Infrastructure Index puts Ethiopia at 52out of the 53 African states (AfDB, 2011). Therefore, given the infrastructure backlog and thegeo-demographic situation of the country, Ethiopia's need to meet its infrastructure demands isstill considerable.

Particularly, nearly all road projects financed by internationalfinanciers were awarded to foreign firms due to the supported reason that the local constructionfirms lack the capacity and capability to satisfy the qualification criteria set by the financiers. In addition, projects delivered significantly fail under the conventional project success criteria ofon time, within budget and to the required performance delivery (ERA, 2009). For example, outof the twenty four rehabilitation and trunk road upgrading projects completed up to 2009 underthe RSDP (Road Sector Development Programme), only seven were completed within budget. The remaining seventeen were completed, on average, 165% over budget. In a study presented in Wubishet (2004), low capacity and capability of local firms is cited as the major reason for the award of projects to international firms and also characterizedthe Ethiopian construction industry as composed of firms with an inadequate capital base, specifically to construction contractors, old and limited numbers of equipment and low levels ofutilization, deficiencies in human resources with regard to technical, managerial, financial andentrepreneurial skills. In addition, Wubishet (2004) found out that, there is noconsistent project planning, coordinated execution and monitoring systems developed (or at leastconsistently adopted) to guide the creation, development and implementation of projects.

Within the context of Dire Dawa, although no quantitative data was ever recorded to depict the common problems of the public construction projects, the issue is investigated in this research.

There are many interrelated contributing factors to the inefficiency of a construction projects such as low productivity, low quality of end product, projects time and cost overrun. Low productivity as identified by Kadir et al. (2005) was mainly caused by poor design constructability, coordination among project participants, and rework due to construction error. Meanwhile, the low quality of the end product is also caused by poor design and constructability in addition to ineffective supervision, lack of skilled manpower, inadequate and inappropriate technology utilization for both design and construction stage, financial problems and lack of information at point of use (CIMP, 2007).

Werku , N. Jha(2016) identified among their findings in their research that the most common form of time delay in construction projects is caused by inadequate drawings and specifications, owner's changes in design or materials, infective project planning, scheduling or resource management, delay in progress payments for completed works.

A.Denamo(2016) studiedaiming solution to achieve sustainable infrastructure in Ethiopia and he described that implementation of sustainable infrastructure development in Ethiopia is still at its infancy. Among all the factors, fragmentation was identified as one of the biggest contributing factors. In the traditional design and delivery approach where sustainability issues are not adequately addressed, resulting infrastructure becomes fragmented that is highly unsustainable and vulnerable. Due to presence of huge input and complex process in sustainable infrastructure design and delivery, the need for innovative information based interventions like Building Information Modeling (BIM) is inevitable (A.Denamo, 2016).

Building Information Modeling (BIM) is a process and technology that supports virtual design and construction methodologies putting all team members together throughout the entire design and construction process and beyond to the operations in maintenance of the building, during its working life. Typically, BIM is one holistic process using real-time, intellectual modeling software effectively working in 3D, 4D (3D + time), and 5D (4D + cost) to improve productivity, to save money and time in the design and construction phases, and to reduce operating costs after construction (Micheal, 2013).

Designers all over the world are implementing BIM as a new technology for their firms. According to McGraw-Hill Construction Report (2012), BIM adoption in the USA expanded from 49% in 2009 to over 71% in 2012. In the UK, the government introduced a progressive program for mandated use of fully collaborative BIM for government projects by 2016 to reduce project delays and cost overruns as part of the overall economic development (UK Government, 2011). In Singapore, the government provides BIM funds to promote a broader usage of BIM technology (Singapore

Government, 2013). In contrast, the Ethiopian construction industry is not tapping the potential of BIM.

The study presents the potential applicability of BIM in addressing the construction problems in Dire Dawa public construction projects. Potential benefits of BIM to Dire Dawa public construction projects, and problems that could be solved by application of BIM, will be investigated. Following are a few potential advantages of BIM that Dire Dawa public construction projects could tap: visual coordination, accuracy and consistency of data, collaboration, easy quantity take-offs, scheduling, to combine various models (i.e., architectural, structural and MEP (Mechanical, Electrical, and Plumbing) models); and to purge conflicts—all in the initial conceptual and design phases(Yoders, 2013).

According to Eastman et al., (2008) and Smith & Tardif (2009), most of the information used on a construction project originates in the Computer Aided Design (CAD) drawings. However, these have limited capability to serve as a data repository, are labor intensive and time consuming to produce, check and ensure consistency and are un-computable where the personnel who receives the information is required to interpret, decode and re-enter the data manually for further use. Consequently, it sets up ineffective activities and creates much room for error in the information production and flow. In addition, its complexity has also amplified the disadvantage of CAD drawings where it was estimated 98% of the industry could not understand drawings accordingly (Lee et al., 2003).

BIM as an approach to building design and construction distinguishes it from other technologies. This lies not only on the advantages of 3D parametric modeling, but also the structured information that is organized, defined, and exchangeable. The structured information opens the door to more effective communication and collaboration at every critical juncture of project lifecycle (Smith, Tardif, 2009). The BIM approach can overcome most of the problems as discussed previously by increasing the design certainty, improving consistency and easing the coordination of design production and providing a seamless information flow and communication. As for tackling the fragmentation problems, BIM as the repository system has attracted many endeavors to expand the capability of BIM. (Marshall, Aouad, 2005).An innovative approach to building design, construction and management is gradually being implemented by major countries across the globe. This paradigm shift is referred to as “Building Information Modeling” or simply put “BIM”.

1.2 Problem Statement

The construction industry is undoubtedly a national asset whose development ought to reflect thedevelopment and transformation of a wider society. Moreover, a nation's economic growth isaffected by the physical infrastructure that is delivered by the construction industry and its keyparticipants. Therefore, it is imperative that the construction industry needs to improve itscapability and delivery system to meet social and economic objectives.

The Ethiopian construction industry issaid to harbor many inefficiencies and ineffectiveness in its delivery system and processes (MoWUD, 2001; ERA, 2009). These inefficiencies result in a significant impacton the country's already constrained resources by: allocation of extraresources needed to implement the projects, a necessity to maintain infrastructure before theirdue period and not delivering the intended purpose the projects are incepted for. One of the causes of the inefficiencies is the lack of a consistent system that identifies the majorconstruction processes and presented 'better practice' on how they are effected (Wubishet,2004).

The performance of construction industry is one of the major development constraints in developing countries since their development highly depends on the growth of their physical infrastructures (Wubshet, 2004). However, most of these infrastructure projects in developing countries encounter considerable low performance in terms of time, cost and quality .Ogulana et al. (2004) and Wubshet (2004) described that many of these performance related problems are recurrent and serious.

Werku , N. Jha(2016) in their research investigated the construction delay problems(time problem). Among their findingsthe most common form of timedelay in Construction projects is caused by, owner's changes in design or materials, Infective project planning, Scheduling or resource management, Delay in progress payments for completed works and inadequate drawings and specifications are identified.

A.Denamo(2016) has described that implementation of sustainable infrastructure development in Ethiopia is still at its infancy. He also identified thatamong all the factors, fragmentation was identified as one of the biggest contributing factors.

Liu et al. (2010) studied the internal readiness of the AEC industry and the organizations that intending to implement BIM and found, the internal readiness is influenced by four factors, i.e. financial cost implications, early recognition of the benefits of BIM, top management attitudes and support for the adoption of BIM and the level of flexibility to implement the change.

A major setback to the implementation of BIM in Dire Dawa public Construction projects as a solution to common construction problems, as with every novel technological innovation across the globe, could be related to the lack of knowledge of BIM technology among Dire Dawa public projects stake holders. It is thus imperative, as a first step, to present the splendor benefits and application of BIM in the adopter countries worldwide by reviewing research literatures, next determine commonexisting problems in Dire Dawa public projects, thentoidentify which problems could be solved by the implementation of BIM from the theme of Literature Reviews, and finallythe level of knowledge of BIM among Dire Dawa public construction projectsprofessionals will be assessed. This in turn, will serve as a basis for developing strategies for increased awareness in order to encourage a holistic implementation of BIM by all construction stakeholders, and thus, achieve the needed productivity and efficiency in the Ethiopian construction industry: the case of Dire Dawa public projects.

1.3 Significance of study

The study will benefit Dire Dawa Public construction project professionals, construction stakeholders and also thegovernment as an owner of many public construction projects by introducing BIM. Additionally this study will contribute to existing knowledge by assessing the potential applicability of BIM technology to the construction industry .It also aid people from the sectors such as architects, construction and civil engineers, mechanical, electrical and plumbing services (MEP) engineers, heating, ventilation and air-conditioning (HVAC) engineers, technicians, contractors, subcontractors, manufacturers, project managers, facilities and operations managers (FM & OM), quantity surveyors, consultants by introducing new way of working.

1.4 Research Objectives

This research aims to assess the potential applicability of BIM in the construction industry of Ethiopia –the case of Dire Dawa public projects. With these aims in mind, the specific objectives of this research are as follows:

To show the potential applicability of BIM to Dire Dawa public projects

- To assess constructionProblems in Dire Dawapublic construction projects.
- To identify the problems that can be addressed using BIM technology.
- To assess DireDawa public construction professionals’ awareness towards BIM.
- To show some applications of BIM using a case study project on A G+4 Building.

- To recommend directionsfor increasing knowledge of BIM in the construction environment towards achieving better productivity and efficiency.

1.5 Research Questions

To get solution for above raised problems, the research questions are as follows

- What are the problems in the construction industry of Ethiopia: the case of Dire Dawa public construction projects?
- Which problems in public construction projects of Dire Dawa could beaddressed by BIM?
- How is the awareness level of BIM among professionals in Dire Dawa public projects?

1.6 Outcomes

The outcome of this research will be :

- An understanding of the problems in Dire Dawa public construction projects.
- An understanding of how BIM technology potentiallybenefits public construction projects in Dire Dawa town

1.7 Research Methodology

In order to achieve the objectives which have been set out by this research, the following methodology has been deployed:

- The review of related literatures on the concepts of potential benefits of BIM to construction industry and the investigation of the BIM technology.
- Assessing problems in Dire Dawa public construction projectsby interview ofprofessionals from public Construction firms (Consultants and Contractors).
- Identifying the construction problems in Dire Dawa public construction projects that BIM could address.
- Investigating how other countries of the world used BIM to solve problems in their construction industries.
- Developing a G+4 building Model on BIM software, Revit,to illustrate the potential benefits of BIM, and its applicability to the public construction projects of DireDawa town.

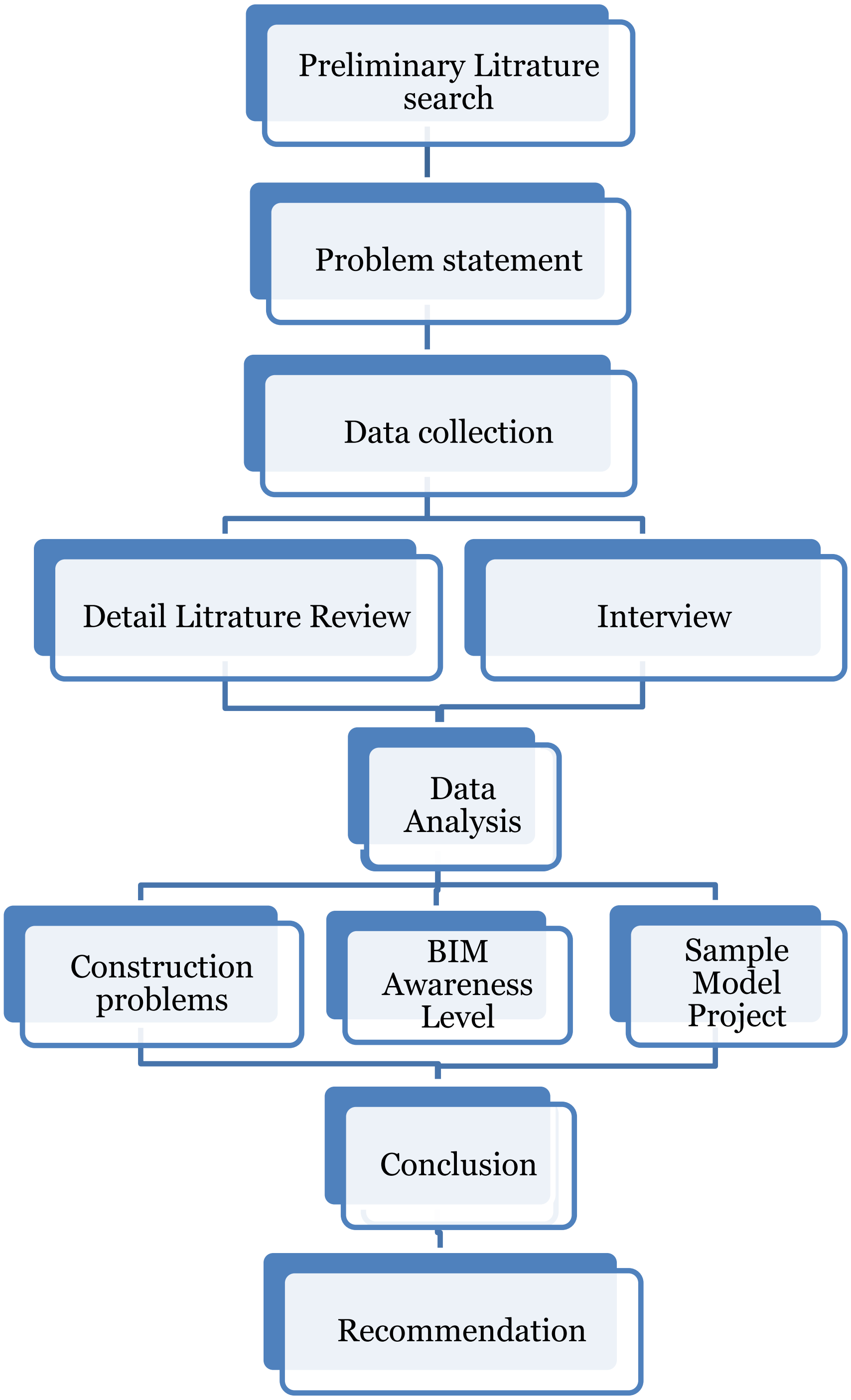


Figure 1: Research methodology flowchart

1.8 Overview of Thesis

Chapter 1 presents an introduction to the research: the background, a problem statement, significance for the study, the aims and objectives and finally the methodology.

Chapter 2 detailed review of the related literature and research pertaining to the problem being investigated, specifically about BIM technology, its benefits to construction industry, the factor that triggered for its adoption in other developed and developing countries, the problems that are solved by using BIM.

Chapter 3 describes the methodology: Presents the chosen methodology for the research and the method for collecting, organizing and analyzing data which support the various studies and findings.

Chapter 4: Presents the results of the study, and analyses these results in relation to the literature and current field of research.

Chapter 5 Presents a case study project on a G+4 Apartment building

Chapter 6 will conclude the study and make recommendations for future research in this field

2. LITERATURE REVIEW

2.1 General description of the study area

2.1.1 Location

Dire Dawa city is located between 9027’N and 9049’N latitude and 41038`E and 42019`E longitude, and in the eastern marginal catchment of Awash basin .East Hararge Administrative zone of Oromiya Regional State borders it in the south and southeast and *Shinele*zone of Somalia Regional State in the north, east and west. Dire Dawa has a total area of about 66,017ha of which the south and south-eastern part of the city which is characterized by a chain of mountains and upland covering 45%; low lying flat land accounting for 40% of the land area; and the remaining 15% is coveredby gorges, valley and River terraces (Ministry of Water Resources,2006).

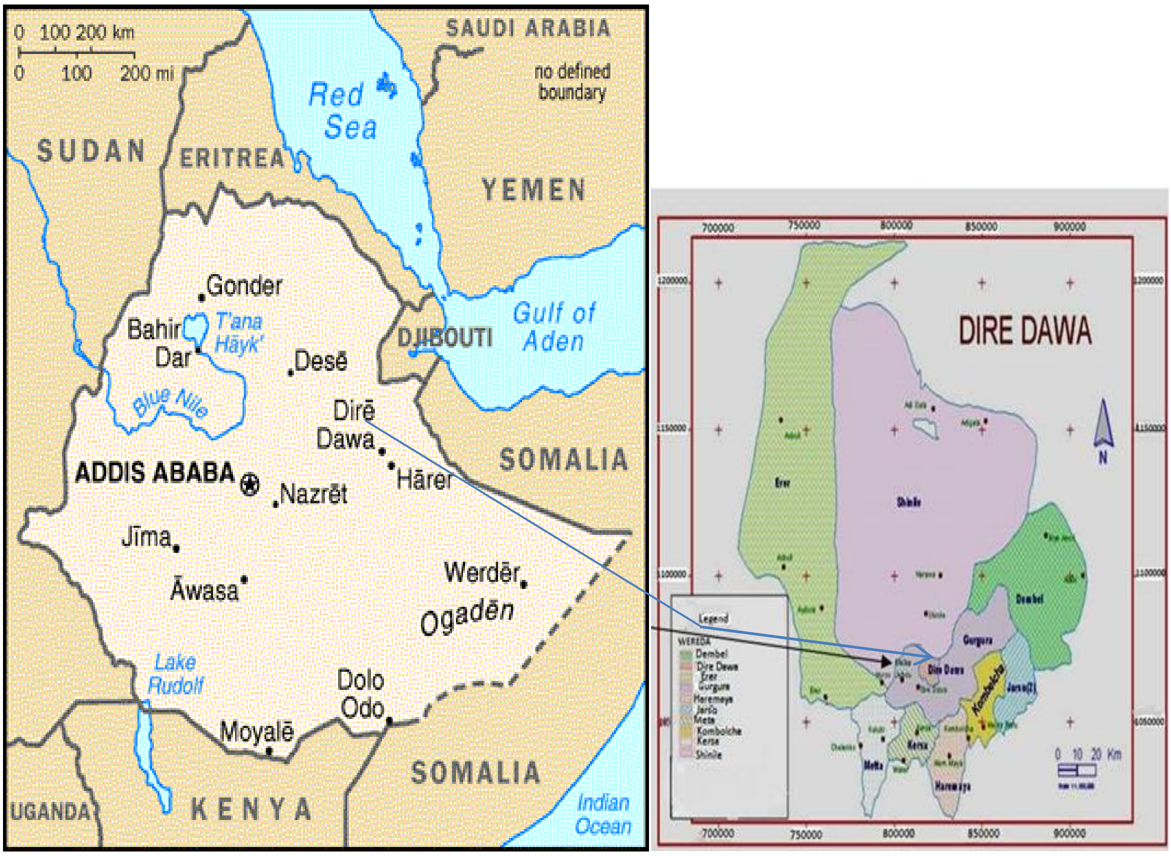


Figure 2: Map of Study Area (Ethiopia and Dire Dawa)

2.1.2 Population

The total population of Dire Dawa city is estimated to be 400,000 people (IDP, 2006). According to the 1994 Central Statistical Agency census result, Dire Dawa city had a total population of 252,000 during the census period and in the year 2005; the population of the city has reached 389,851 which exceeded the census period population by 137,851. More than half of this increase is due to migrants from nearby rural areas and other part of Ethiopia. Since Dire Dawa is one of the industrial and business cities in Ethiopia, people from rural areas perceived that job can easily be secured in the city. The increment within a decade accounts for more than half of the size of the 1994 population, which is tremendous in magnitude (Integrated Development program, 2006).

2.1.3 Construction in Dire Dawa

Being -one among the large cities of Ethiopia, Dire Dawa contributes much to the growth of Ethiopia. It is studied by many researchers that the Ethiopian construction industry is said to harbor many inefficiencies and ineffectiveness in its delivery system and processes (MoWUD, 2001; ERA, 2009).So as a city Dire Dawa city Administration has put prior plans to enhance the growth of the city; among these improved system for the production and provision of infrastructures is included (United Nations Human Settlements Programme,2008).

Researches related to the construction inefficiencies and problems are not only available but also there are almost no researches that are available on the internet. So this paper will add some knowledge regarding the common construction problems in Dire Dawa public construction projects. Not only this but it will present the potential benefits of the world’s innovation BIM to benefit Public construction projects from it, and finally recommends future preparations to tap the rich benefits of BIM.

2.2 What is BIM?

The National Building Information Modeling Standards: defines BIM as a digital representation of the physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as exiting from earliest conception to demolition. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholders (NBIMS, 2007).BIM is an intelligent model-based process that provides insight to plan, design, construct, and manage buildings and infrastructure.

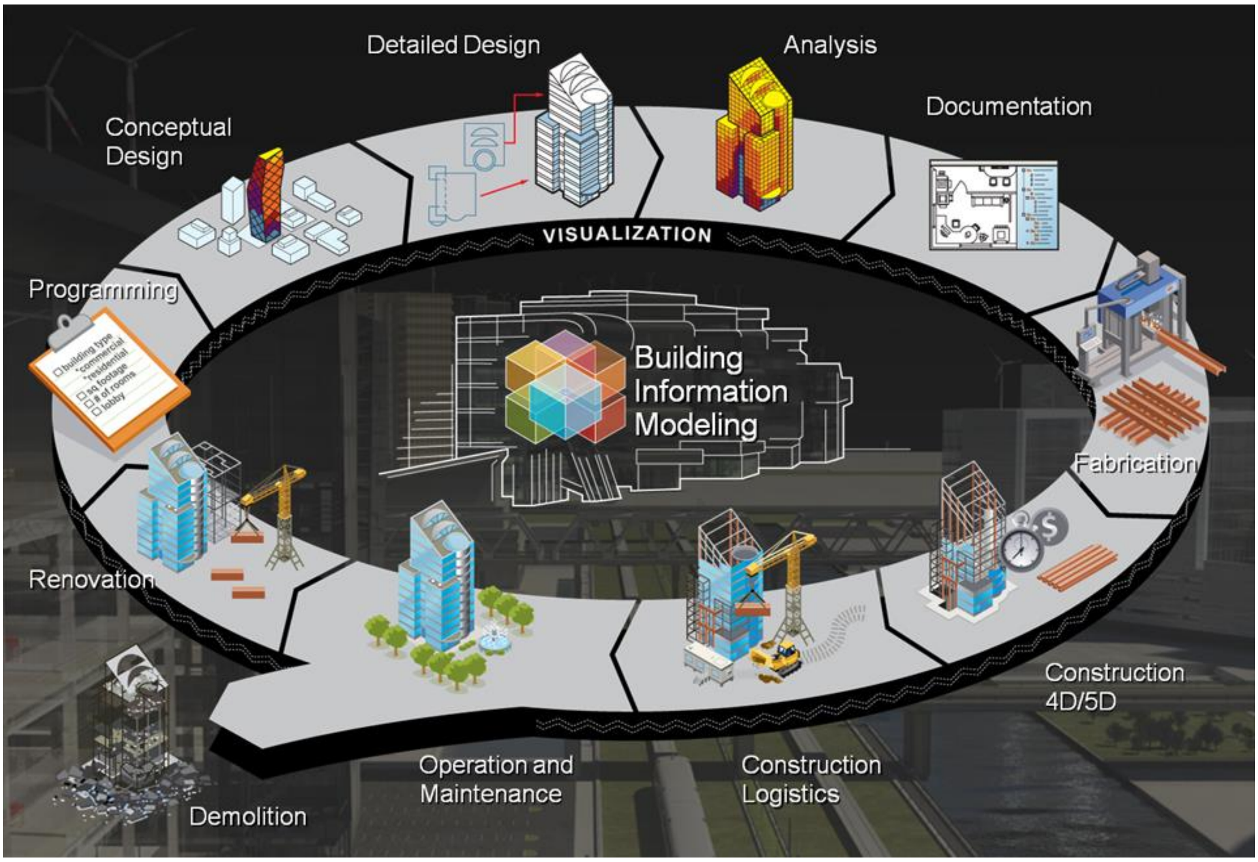


Figure 3:BIM Lifecycle(source:BIM strategy,2011)

In simple terms, BIM is a tool to collaboratively design various elements of a structure in 3-D format and provides a better means to visualize and analyze these structures. In actual, a BIM design is equivalent to virtually designing a structure which shows virtual elements of actual building parts and pieces used to build a building. These virtual elements are digital prototype of physical building elements that allows us to simulate the building and understand its behavior in a computer environment way before actual construction starts. BIM provides a much better means of communication and distribution of information between clients, construction and architecture firms and legal authorities involved in project.(Kushwaha,2016)

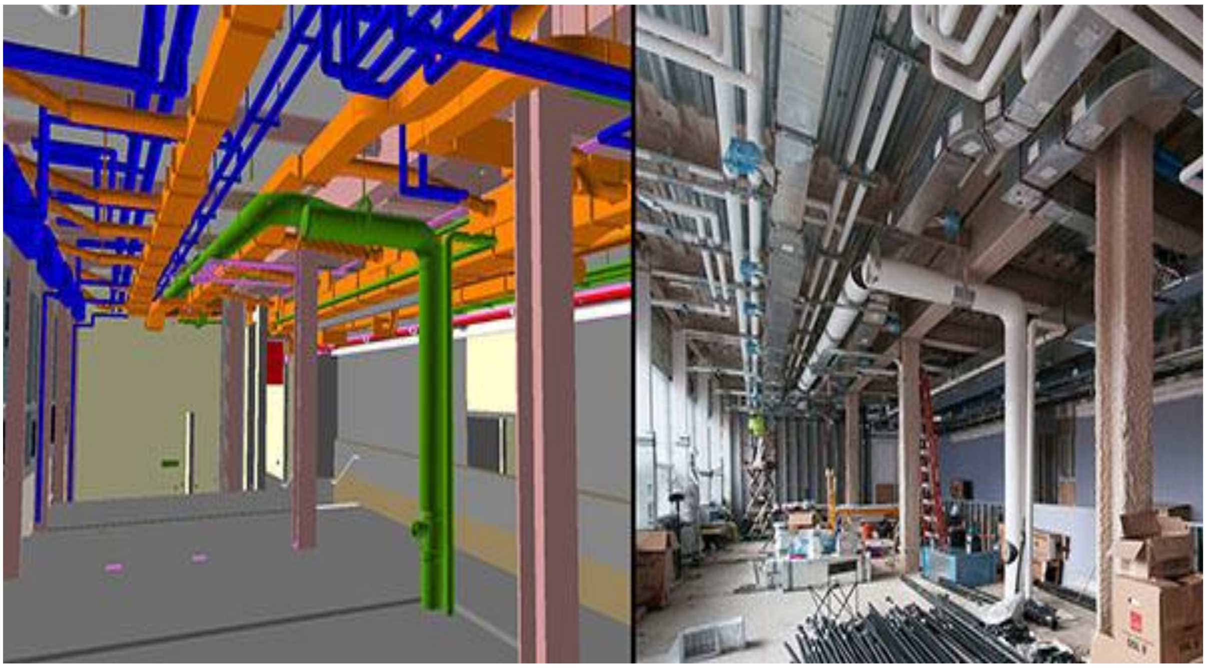


***Figure4: Virtual designing using BIM with actual construction of same BIM design*.**

BIM is to a great extent based on these 3D models which are created during the design phase where designers add parts and put them together to shape a building in a virtual environment. Eastman et al. (2011) held that BIM transfers construction from drawings and spread-sheets into a process of collaborative and coordinated efforts between its actors and enables the capturing of information. Prior to this it was explained that:

"BIM represents real world elements-such as walls, doors, and windows-as three-dimensional (3D) objects. In addition to geometry details, other information can be attached to these objects including manufactures, fire rating, schedule, and cost estimates."(Goedert ,Meadati, 2008)

The steady development of increasingly sophisticated software, that enables construction companies to put more detailed information into digital representations, has served as a source for radical ideas. In developed countries, early Adopters see BIM as a solution to numerous challenges and obstacles encountered in construction projects.

It is attributed that the term ―BIM was first coined in the late 1970s by Charles M. Eastman and the concept of Building Information Modeling has been first used in the mid-1980s (Eastman, 1975). Later definitions of this term include the one by Phil Bernstein (Kiviniemi, 2010) and many others who have followed.

Nowadays, more and more owners and Architecture/Engineering (AE) firms in UK, USA and other world countries have introduced the concept of BIM using 3D modeling to support both the preconstruction and the construction process. Many new terms, concepts and BIM applications have been developed such as 4D, 5D, 6D and 7D. The —D in the term of 3D BIM means —dimension and it has many different purposes for the construction industry. 3-Dimensional means the height, length and width. 4D BIM is 3D plus the factor of time, which in the context of BIM used in construction planning implies, the project schedule; 5D BIM is 4D plus cost estimation; 6D BIM is 5D plus site, which means a 3D building model linked with a 3D site model, and the integrated model should also carry all the project schedule and estimation information; and even the concept of 7D BIM has been brought up, which is BIM for life-cycle facility management (Review of BIM, 2011).

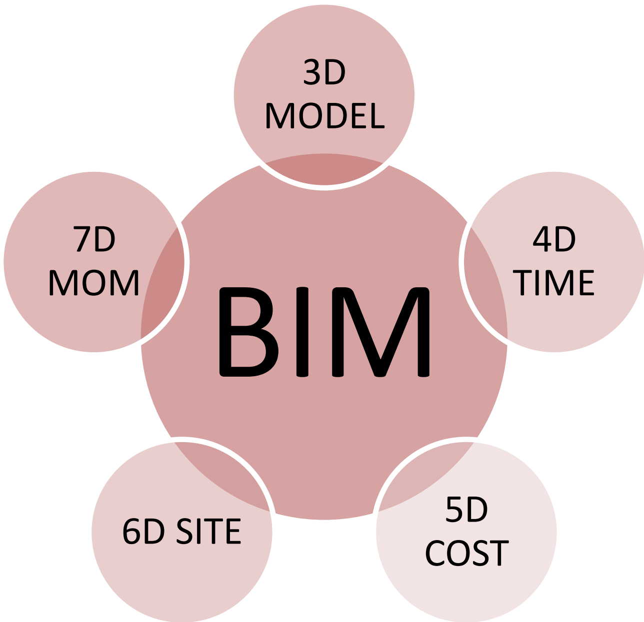


Figure5: BIM Dimensions

Through a wider and wider application of BIM, certain benefits have been found out and confirmed by researchers. The key benefit is its accurate geometrical representation of the parts of building in an integrated data environment allowing for a more coordinated production of documents in 2D and 3D, it provides a better visualization of the design which would help the owner to confirm if the final building would meet his/her expectations; meanwhile, BIM as an single integrated information resource, would make the communication and coordination among project participants much easier. Some other benefits of BIM are faster and more effective processes, better design, controlled whole-life costs and environmental data, better production quality, automated assembly, better customer service and lifecycle data for facility management (Azhar, 2011).

Figure 6: collaboration between project stakeholders during lifecycle of building

2.3 BIM History

2.3.1Background of BIM technology

In the Handbook on BIM (Eastman et al., 2008), Laiserin suggests that BIM was built using existing modeling principles, but with a change to the aspects of different names such as Product Model, Information Model and Data Model. Until the early 1980's, this technology approach was described as "Building Product Models" in the USA (Georgia) and as "Product Information Models" in Europe. Liaserin (2002) helped to support the adaptation of the term BIM after it was first used by Phil Bernstein, an architect with Autodesk (Succar, 2009). The concept of a product model is common to both approaches and constitutes the key intellectual idea underpinning the technology and entails agreed data structures with comprehensive ability to capture engineering information about a particular class of artifact (Watson, 2010). The standard for the Exchange of Product model data

(STEP-ISO 1030), used for engineering works, industry foundation classes (IFCs), general building information and CIMsteel integration standard (CIS/2) and for structural steel works are common examples of product models.

Today there are many definitions of Building Information Modeling (BIM) from a variety of stakeholders in circulation (Eastman et al., 2008). One of the earliest definitions of BIM was introduced by Prof Charles Eastman at the Georgia Institute of technology whose theory is based on the view that the term "building information model" is the same as a "building product model’’ (Eastman, 1999). According to Eastman, BIM digitally models buildings for design and construction processes, so as to record all the information about the attributes and properties of the model. NIBS (2007) also defined BIM broadly as being a computable representation of the physical and functional characteristics of a facility and its related project/life-cycle information, which uses open industry standards in order to inform a business managements’ decision-making (Jaradat, 2012). In addition, (Fortner et al., 2008) highlighted the fact that some designers claim to have used BIM for their projects when in reality they have simply used 3-D modeling as a visualization tool, omitting the transfer of information that would have made the method a true BIM process. The definition provided above by the NIBS (2007) implicitly covers basic BIM features such as the creation and operation of the digital database for the collaboration of different stakeholders at different phases of the lifecycle of a facility, in order to insert, extract, update or modify information in the BIM and to support and reflect the roles of that stake holder (Jaradat, 2012). A BIM includes all relationships and inheritances (predefined hierarchies) for each of the building components it describes; in that sense it is ‘‘intelligent’’ (Bazjanac, 2008). It is therefore clear that BIM is a process which involves the structured sharing and coordination of digital information about a building project throughout its entire lifecycle; from design through to procurement ,construction and beyond in to the operation and management stage. This involves the use of coordinated 3D design models that are enriched with data, and created and managed using a range of interoperable technologies.

2.3.2 The fundamental of the BIM technology and scope

One of the key primary technologies that distinguish BIM design applications from the other CAD systems is its use of Object-based parametric modeling. This allows for the virtually modeling of real construction elements such as walls, windows, slabs and roofs, etc. , in advance of their physical realization thus delivering greater cost certainty, eliminating error, improving program duration and reducing risk (Eastman et al., 2008).Teicholz et al. (2008) underline the fact that for BIM everything starts with a 3D digital model of the building. This model, however, is way more than pure geometry, as it also for visualization. A true BIM model consists of the virtual equivalents of the actual building parts and pieces used to build a building. These elements have all the characteristics of their counterparts, both physical and logical. These useful elements are the digital prototypes of the physical building elements such as walls, columns, windows, doors, stairs etc. that allow us to stimulate the building and understand its behaviour in a computer environment before the actual construction starts (Eastman, 1999).

BIM represents objects by parameters and rules that determine the geometric and non-geometric properties and features (Lee et al, 2007). Objects are automatically updated based on the inherent parametric rules according to user control. For example any revision made in the structural BIM model will reflect automatically in coordinated other views (e.g. architectural, materials and so forth) without requiring user's interaction in order to manually update information (Eastman et al., 2008). To describe it clearly, Current BIM software technology provides interoperability between the 2D paper drawings, Excel spread sheets, construction schedules and other 2D information and the BIM model. If the design is changed in 3D model, the 2D information is automatically updated. Similarly, if the design is changed in the 2D document, the 3D model is also automatically updated. This interoperability saves time, reduces errors and can provide advantage to the designers, while ensuring consistency between all types of information documenting the project (Eastman et al., 2011). Using BIM the construction site documents for instance the drawings, procurement details, submittal processes and other specifications can be easily interconnected (Khemlani, 2007).

The great intelligence of BIM lays in the fact that it is able to collaborate building information, integrate a multidimensional approach to design, whilst also being able to combine all the life-cycle phases of a building in the form of a single digital virtual building. BIM is therefore able to cover planning and design (sustainability information, 3D, 4D, 5D and nDmodeling), construction (construction management and coordination), operation and maintenance (retrofitting, energy simulations) and demolition (waste management, reuse and recycling,). This therefore allows BIM to reduce problems allied to waste in the construction industry (Eastman, 1999).

2.4 BIM technology Applications and uses

The purposes of using BIM (Eastman et al., 2011) include:

- Visualization: 3D clarification can be easily produced using BIM.
- Fabrication/shop drawings: once the building model is created it's easy to produce fabrication drawings using BIM. Enabling off-site fabrication
- Forensic analysis: potential failures and leakages are described graphically using BIM
- Facilities management: planning and management operations are easy using BIM

- Cost estimating: once the model is complete material quantities are extracted for a given model specifically using BIM.
- Construction planning and scheduling: to order the material, fabrication, scheduling information for clarification of necessary manpower.
- Conflict, interference and collision detection :detection of interference of conflict is solved using BIM
- Controls and Minimizes the Cost of Project: The application BIM optimizes the resource utilization and minimize the waste generated in project. A significant amount of funds is saved by the prefabrication and scheduling aspects of BIM.

Table1: BIM Benefits. (McGraw Hill Construction, 2012)

Long term BIM benefits	**Short term BIM benefits**
• -Fewer Claims/ Litigations • Reduced Construction Cost • Increased Profits • Reduced Project Duration • Marketing New Business	• Reduced Conflicts • Better Understanding of Design Intent Among Team Members • Enhanced Project Quality • Decrease in Number of RFI's • Better Construction Cost Predictability

One of the main advantages of implementing BIM applications is the visual coordination and the capability to identify possible conflicts among the various building systems. Furthermore, the instantaneous data updating attribute of BIM along with cloud computing, helps AEC professionals tremendously in saving time, otherwise spent or wasted in exchanging project information. These deliverable products are just a few things that one can expect from this powerful tool which completely transforms the way business is performed (Franklin, 2010).

The advantages and possible benefits of this new technology compared to traditional 2D CAD have been researched intensely in various nations. BIM offers a plethora of benefits, both directly and indirectly, to all members of the AECFM industry. A reduction in conflicts and changes/rework during construction, low levels of risks and improved estimate of long lead resources , overall reduction construction wastage and the whole-life costs of built assets, better-performing completed infrastructure, and improved overall project quality are among the advantages that can be experienced with appropriate usage of BIM applications and solutions.

3D Model: The ultimate goals of BIM are to increase efficiency in terms of time, costs, accuracy and thoroughness, to increase communication, and to increase collaboration (Hardin, 2009). An accurate representation of a finished project product can be visualized at an earlystage in intelligent Building Information Models. Communication of design and engineeringsolutions between stakeholders in the project is less complicated and more effective. Modelsand their integrated information are always updated, and BIM allows for real-time designadjustments and development. This generally improves communication and helps disciplineswork together toward a common goal (Hattab,Hamzeh, 2013).

The model'sinteroperability & the digital information sharing eliminate many possible communicationerrors. Digital Requests for Information (RFI) can be produced through BIM, and theinstallation of fabricated components is visible in the model (Hardin, 2009). Rework anddowntime on site is reduced due to the fact that all discipline models are integrated into onecentral multidisciplinary model. This gives project participants the ability to assess the impactof changes on the overall design more realistically & in real time (Hattab ,Hamzeh,2013).

Client involvement and client satisfaction are increased when using BIM. The client'sinvolvement throughout a BIM project will translate the client's value preposition properly (Hattab,Hamzeh, 2013). And in the future, the 3D model can be made into a physicalmanifestation by using 3D printers (Vandezande et al., 2011).

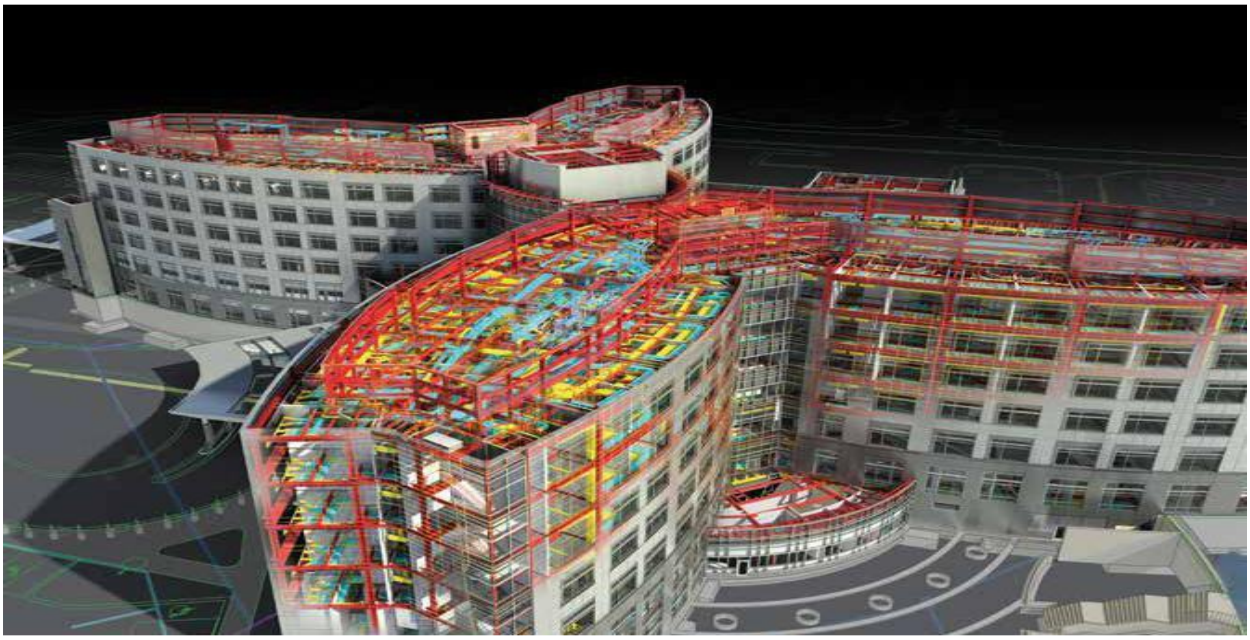


Figure 7: 3-D model design of a building using BIM.

4D Time: With time estimation, also called 4D BIM,the objects in a building information model are linked to the time plan. The linkage to time plan makes it possible to graphically visualize the objects schedule and users can simulate the building site and construction at any point in time. This type of simulation provides considerable insight and allows for early detection of planning errors. Instead of realizing planning mistakes later on in the construction phase, and having to resolve problems on site which can be very costly, mistakes can be eliminated already in the design phase (Eastman,et al., 2008).

Adding one dimension opens for the ability to schedule systems, materials and quantities through4Dvisualization. Multiple sequencing and scheduling alternatives can betested and evaluated for cost and/or feasibility through this application (Harris and Alves, 2013).Using annotation on 4D BIM models can help explain prospective constructionproblems, making the model supportive to decision making. Trade coordination involvesworking and communicating with contractors and subcontractors, crew supervisors, supplierand fabricators, which becomes more demanding as the project size and complexity increases.

Trade coordination is one of the areas where BIM really shines (Hardin, 2009). The project'sconstructability is ensured through analytical features such as collision control. The value ofBIM as a multiple trade coordination tool increases every time collisions are found, tracked,and resolved before a project reaches the construction phase. The collision detectionresolution and reporting allow construction site managers to utilize BIM as an organic meansof finding issues with models provided by engineers and subcontractors (Hardin, 2009).Implementing the system pointed to positive potential effects for site personnel'sability to visualize the process itself, with reduced time wasted looking for work.

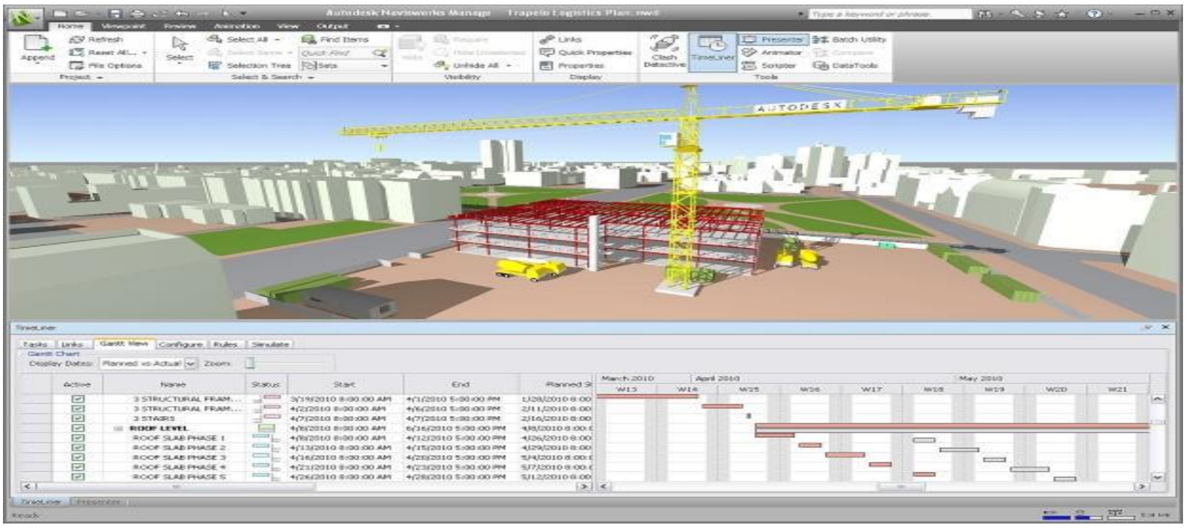


Figure8: Scheduling timeline is collaborated with 3-D Model of Structure taking time as 4D

5D Cost: When the construction and design team is working collaboratively using BIM, many benefits can be experienced; for example, quantity take-offs and cost estimation are just few among many of them. BIM's trait of estimation from the model helps the estimator prepare the material/resources estimation faster, easier, and with fewer errors. BIM allows cost estimates to be more accurate and reliable than those prepared using conventional methods which are subjected to manual miscalculations (Hergunsel, 2011).

"The Stanford University Center for Integrated Facility Engineering revealed that using BIM yields numerous benefits, including an up to 40 % elimination of unbudgetedchanges, cost-estimation accuracy within 3 %, an up to 80 % reduction in cost estimategeneration time, saving up to 10 % of the contract value through clash detection, and an up to7 % reduction in project time" (Chien et al., 2014). Planning the budget and monitoring costsaccrued may be conducted more accurately with BIM.

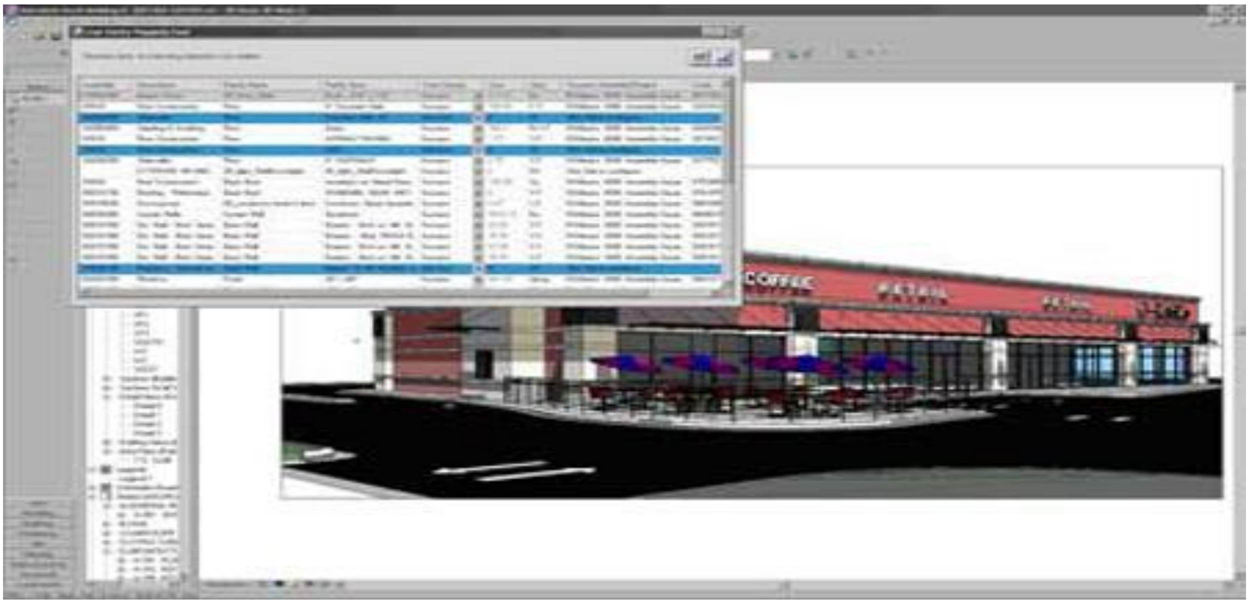


Fig9: An intermediate step in BIM for cost estimation using Autodesk Revit.

6D Environmental Management: Analyses such as energy, lighting, solar impact, photovoltaic potential, rainwater reclamation, computational fluid dynamics simulations, andLEED documentation are different building performance analyses that can be performed onBIM models (Vandezande et al., 2011). The interoperability of the model's geometry andmetadata between applications allows for such analyses.

Fig 10: BIM was used to create sun studies which helped shape the roofs.

7D Facility Management, Operation and Maintenance: A final project inspection iscarried out before the handover of the completed project product to the owner (Hardin, 2009).Building Information Models can be used as punch lists for such work. A 7D BuildingInformation Model is a facility resource with information on warranties, specifications, andmaintenance schedules that can simplify the project closeout and make it a briefer process (Bryde et al., 2013).

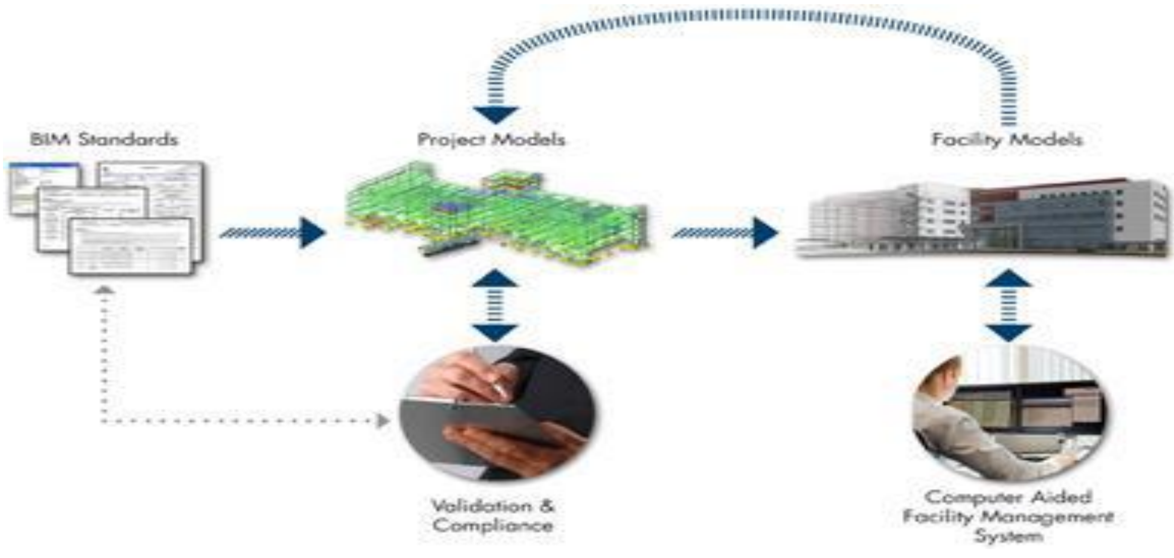


Fig 11: BIM modeling making it useful through every step of Facility Management.

2.5 Construction Industries of world countries & the Impact of BIM

Even if developed countries are facing problems related to construction industries they are defeating most of them through the application of BIM. Some of the most common problems include:

excessive change orders, poor scheduling, inaccurate estimates, scope gap, poor building design, and unqualified labor force (Caldas etal.,2014).From a user's perspective these challenges have supported the emergence and adoption of BIM in developed countries.

Based on the trends identified in the literature it is evident that BIM promised, and delivered, solutions for schedule and cost overruns including improved coordination and communication processes on construction projects. The benefits of construction technology have not been limited to the developed and industrialized countries throughout the history of construction industry. Ofori (1994) argues that the diffusion of construction technology from industrialized countries to developing countries has long been addressing prominent technological problems of developing countries.

Developing countries on the other hand are sharing the same chronic challenges of project delays and cost overruns as industrialized countries. However, to some extent, profound issues have been addressed via adopting technologies from developed countries like Auto CAD, scheduling software, and other design programs resulting in significant time savings. Technology transfer from industrialized countries has focused on addressing the lower level technological development of the developing countries over the last several decades (Ofori, 1994). For example, scheduling software disseminated from developed countries has helped developing countries construction industries develop more reliable and efficient construction schedules and control processes.

Although, technology adoption has helped developing countries alleviate the intensity of challenges, there is still a long list of issues that need immediate attention. Long et.al (2004) found that incompetent designers/contractors, poor estimation, change management, social and technological issues, construction site issues, improper techniques and tools are key factors of construction problems in developing countries. Also, inaccurate time estimating, excessive change orders, resource shortages (including obsolete technology), organizational culture and kickbacks, inaccurate cost estimating, improper planning and scheduling, lack of involvement through project life, and impractical design are ranked consistently as high frequency occurring problems in developing countries' construction industries

Lee et al. (2013b) looked at the ROI based on use of BIM in design validation and prevention of cost involved with rework due to design errors. They found that a total of 709 individual design errors were identified using BIM during the design validation of six medium and high raise buildings in Korea. Additional studies show that the impact of design error on the schedule delay results in a much larger negative economic impact than rework (Lee et al., 2013a). Therefore, it is important for any country to embrace contemporary technologies like BIM to enhance its capacity in order to respond to issues that impact the overall building process success.

The majority of problems relating to delays within the construction industries seem to be similar and persistent in many developing countries (Ofori, 2000). Therefore, the construction industries of USA, UK, Jordan, Singapore, India, and Malaysia were selected to further explore the challenges of countries' construction industries and how BIM helped them in defeating these challenges.

Construction Industry inUSA

Though developed countries are facing problems related to construction industries they are defeating most of them through the application of BIM .Some of the most common problems include: excessive change orders, poor scheduling, inaccurate estimates, scope gap, poor building design, and unqualified labor force (Caldaset al., 2014).

From a user's perspective these challenges have supported the emergence and adoption of BIM in developed countries. Batcheler (2007) used case studies to identify the benefits realized from BIM adoption in the US construction industry. The benefits most frequently reported include: clash detection, consistent and accurate drawings set, early involvement of stakeholders and other project team members, coordinated planning, design, and construction, generation of a prefabricated model for accurate and realistic models, and extensively supporting lean construction techniques. Becerik, Rice. (2010) used a survey and found that BIM was used in Architectural firms for design related functions such as, building design, visualization and building programming and massing studies. Contractors use BIM mostly for clash detection, visualization and generating as built models. Benefits of BIM also encompass the direct fabrication and sustainability aspects of buildings (Gerber, Rice, 2010).

Fortner et al. (2008) documented the importance of BIM in the design and construction of the National Park Stadium project in Washington DC that had a definitive completion milestone. The construction team representative reported the main reason behind the project's success was the use of BIM. The use of BIM advanced representation of the project model which resulted in a shorter schedule time and budget. With little rooms for delays and errors the number of RFIs was reduced. Instead of designing the foundations and concrete work first, followed by steel stands, the stadium was built in circular style from one end to the other resulting in construction schedule that was six months shorter that that originally anticipated.

Construction Industry in Singapore

Internationally, Building Information Modeling (BIM) has been identified as one of the key technologies that will transform the construction industry. Unsurprisingly, Singapore has jumped onto the bandwagon, with the adoption rate for BIM rising from 20% in 2009 to 65% of all constructions in 2014(Wong, 2016).

As it is reported in the study of Wong(2016), the key value of BIM lies in enabling building professionals of various disciplines (architects, structural engineers, structural professionals, M&E engineers and contractors) to explore the building project digitally before it is built. The 3-D model of a project and drawings can be shared among the professionals who can then analyze and resolve potential design clashes before construction begins. BIM facilitates better teamwork among professionals which in turn reduces unnecessary re-works when the project is being constructed.

Ofori.,etal. (2015) used a series of interviews and an online questionnaire-based survey to investigate the views of practitioners on the productivity and BIM application in the Singapore construction industry, and explore the potential of BIM to help in the efforts to improve productivity on construction projects .The respondents acknowledge that BIM has the potential to enhance elements of practice beyond the preparation of models for mandatory submission, through pre-project planning, identification of documentation errors and productivity monitoring using actual construction site data. The paper reported that, BIM is used more widely at the beginning stages of the projects. The study suggest that much more needs to be done to use BIM in a strategic and more sophisticated manner, in particular, to further improve productivity in the industry.

Construction Industry inUK

In order to obtain the UK construction practitioners' approaches and understanding towards BIM for assessing how much the industry has benefited from BIM and the problems solved by BIM service offered ,survey was conducted in a Construct IT workshop. Respondents expressed the services below. (Marshal etal., 2009)

• Construction management, Shop drawing production,increased efficiency leading to improved design,helping clients develop BIM capabilities themselves.

On the other hand, it was seen that there was a consensus amongst the respondents in what issues or problems can be overcome by the implementation of BIM within a firm. All the respondents have indicated the aspects below. (Marshal etal., 2009)

• Efficient collaboration amongst the construction stakeholders

• Availability of the accurate documentation of the building development

• Common understanding of project costs, schedule and project progress

• Ability to assess the design alternatives and lifecycle impact

• Reduced error, rework and waste – so towards better sustainability for design and construction

Construction Industry in Jordan

Jordan's construction Industry is growing at a fast pace (Sweisetal, 2015).Sweisetal. (2008) found the construction industry plays the main role in Jordan's economy leading to employment and wealth. While the construction industry contributes in the country's economic development, construction projects still experience delays which typically results in unreasonable inflation of the original time and cost (Sweis et al., 2008). One of the main causes of construction delays was identified as the contractor's financial inability to fund the project and excessive change orders by the owners. A study on over 130 public projects in Jordan conducted by Al-Momani, (2000) shows that the origin of delays in construction projects can be traced to poor design, increases in material quantities, change orders, site conditions, and economic conditions.

Matarneh, Hamed(2017) conducted a survey to determine the different views of respondents about the major benefits realized through adopting and implementing BIM in AEC construction in Jordan. The survey had 180 complete responses .The "total" category displayed throughout the study includes different stake holders of the construction industry of Jordan such as architects , engineers, contractors , owners, planners, building product manufacturers, government agencies, various integrated firms and consultants.

One of the objectives of the survey was to determine the different views of respondents about the major benefits realized through adopting and implementing BIM in AEC construction in Jordan. Respondents believe that BIM provides multiple benefits. Benefits were almost consistent across most of respondents. From their response, about 95% of respondents agreed on BIM ability to reduce the rework and design errors, conflicts and changes during construction processes to a large extent; thus improve productivity. Moreover, 85% of respondents believed that BIM improves visualization, which resulted in enhancing design scheme options. Consequently, this results in time reduction, and minimizes the cost and maximizes profitability and productivity. 85% of respondents believed that BIM enhance collaboration and communication between the different project entities facilitating early engagement with the relevant disciplines. Moreover, BIM can also help with localized engineering solutions such as design review, project documentation, clash analysis, cost analysis (Matarneh, Hamed, 2017).

Construction Industry in India

The Indian construction industry has been one the fast growing industries in the region and accounts for most of the major investments in India.it is the second largest industry of the country significantly supporting the overall economy while providing employment opportunities. The use of technology and the deployment of project management skills and techniques have resulted in the successful completion of mega scale projects in India (Lasker, Murty, 2004). According to Chatterjee (2013) based on the international counterparts' cooperation with Minister of State for Housing, Mining & Industry, a technology program has recently been launched within the construction sector of Indian government. It is further stated that the recent technology launched is Building Information Modeling and this is supported by Tekla Structures. This will enable architects, engineers and MEP professionals work more efficiently (Swarup, 2007).

A study by Vyas (2013) in India concludes that the major elements impacting delays include equipment issues, employees, decision making power, team work and coordination, and a lack of strategic planning. Delays caused by equipment included a shortage of the right tools for the work, the use of classical tools as a result of organization culture, calibration of equipment, and installation problems. Delays caused by employees include a random approach by employees on how to execute the construction process, a lack of discussion between teams, interpersonal skills, decision making power, weak feedback to the project teams, and a frequent change of manpower.

A range of BIM soft wares are accessible worldwide. Generally Autodesk products are preferred and used by most BIM users in India. In India, BIM is being generally used throughout the design and advance stage, pursued by the construction stage. BIM is seldom used in facility management or facility operation of Indian construction projects. (Sharma, Gupta, 2016)

In the study of Anmolet al. (2015) it is reported that BIM has the prospective to be deployed in the Indian construction sector to offer noteworthy operations to construction stakeholders .some of the key advantages are listed below.

- Cost and time reductions can be achieved on projects through model-oriented processes that BIM permits.
- It develops harmonization among diverse stakeholders such as architects, contractors, supply team and project team etc.

- BIM allows perceiving clashes, maintains precision in quantity assessment & timelines, allows superior cost examining and control, waste cutback, helps to sort out operational & maintenance problem.

Malaysian Construction Industry

There are different arguments by scholars whether construction is an important driver of the country's economy whereas, it surely contributes in providing necessary infrastructure that stimulates economy and national development (Olanrewaju, Abdul-Aziz, 2015). Abdul-ahman et al. (2006) argue that the Malaysian construction industry vitally contributes to the country’s economy. He further introduces the causes of delay in construction projects as variations and planning issues (Abdul-Rahman et al., 2006). As a result of a survey conducted, most of the participants believe that owners are the main reason behind project delays and that they never cooperate with making decisions in a timely (Abdul-Rahman et al., 2006).

The Malaysian government is aware of the benefits offered by BIM to improve the quality of projects in the construction industry. The government has made several efforts to promote BIM by highlighting it through the platform of roundtable discussion with construction players, forums and seminars as well as providing the latest information through portal. The government’s initiatives have contributed to project developments using BIM in the construction industry. In 2010, the first government project using BIM was planned and the project is known as the NCI project, which was completed in August 2013. The project shows the benefits gained from using BIM, which are reflected in the minimization of waste in terms of time and cost, leading to improve quality of the project. With the use of BIM for designing the project, clashes could be detected before the construction process began. Hence, no rework for the project was needed, eliminating any additional construction costs. The success of the project has led to more government projects using BIM. Abdul-Rahman et al., 2006).

2.6 Summary of Literature

Many contractors, architects, designers, and engineers in developed countries such as the USA and the UK are practicing this BIM for better productivity and efficiency with infrastructure projects (UK Government, 2011). This technological advancement and recognition of BIM in Ethiopia is in absolute contrast to status in developed countries. Although Ethiopiahas a rising and expanding in construction industry, but the country’s architects and engineers work processes are performed using the traditional practices. These traditional processes are also there in Dire Dawa public constructionprojects.

3. METHODOLOGY

3.1Introduction

It was decided to carry out this research work using an inductive research approach, andqualitative research methods to collect data. An extensive literature search was conducted inorder to gain understanding of theory and previous research on the topic. Data was collected throughsemi-structured open-ended and closed ended interviewquestions, asked to DireDawa public construction firms ‘professionals. In this approach interviewer‘s major task is to build upon and explore their participants’ responsesto those questions. The goal is to have the participant reconstruct hisor her experience within the topic under study.

Schuman(1982) designed the series of threeinterviews that characterizes this approach and allows the interviewerand participant to plumb the experience and to place it in context. Thefirst interview establishes the context of the participants’ experience. Thesecond allows participants to reconstruct the details of their experiencewithin the context in which it occurs. And the third encourages the participantsto reflect on the meaning their experience holds for them.

As Schuman (1982) supportsthis interview has three parts. The first part is about participants’ experience and area of expertise, the second parts is about common construction problems in the participants’ projects, and the last part is about participant’s perception towards BIM.

3.2 Literature Study

A literature study is done by researching and reviewing current knowledge including substantive findings, and theoretical and methodological contributions to a particular topic. The purpose of a literature study is to identify areas other researchers have overlook, which will emphasize how this research will contribute to new knowledge (Everett,Furseth, 2012).

A literature study is a necessary part of a scientific project. A literature study discloses whatinformation is already out there, and clarifies what research is still unexplored. By accountingfor literature in the field, the researcher shows that he is familiar with relevant andimportant literature on the area. A literature study also prevents one from doing unnecessarywork or rework.

Internet was used to get insight in recent research discoveries and inventions, through journal articles and conference papers. They helped shape the focus and the purposeof this master thesis by providing information about BIM’s many potential future functionsand research areas.

Published journal articles and conference papers may be considered more reliable than traditional master thesis due to the fact that such publications have been carefully reviewed and revised by a panel before being published. Scientific articles and papers were utilized for four reasons:

- To become familiar with recent research on BIM,
- To find an incomplete and appropriate research area for the master thesis,
- To use the publications' contents as theoretical framework, and
- To use the publications' references to find additional literature.

3.3Validity and Reliability

Literature is commonly evaluated based on its validity, reliability, objectivity, accuracy, and adequacy. The literature study's validity and reliability, and the literature's reliability, and relevance to the research problems were considered most important in the selection process. Validity is defined as "the ability of an instrument to measure what is designed to measure". Reliability measures if the research tool is consistent, stable, predictable and accurate. It determines if a research instrument will provide the similar results under the same conditions (Kumar, 2005).

The researcher attempted to ensure the research method's validity by reviewing and utilizing articles with various focus areas within BIM, which together provided a fairly comprehensive outline of BIM.Most of the literature selected deals with BIM, its benefits, applications, and its benefits to Adopter of it. Only literature relevant to the research problem was used as theoretical framework in Chapter 2.

BIM is not a new technology to the developed countries, so there is a lot of information available about it. The concept of BIM was first published decades ago (Eastman et al., 2011). The reliability and objectivity of research on and information about BIM varies greatly, partly depending on who has ownership over that information. The data's reliability was primarily evaluated based on the authors' reputation in the context of research, the authors' objectivity and whether the content matches independent research.

The weakness associated with this literature study was, there are almost no researches are made in the Area of BIM technology in Ethiopia. Only one survey paper worked in Addis Ababa institute of Technology University was found, So many literature reviews and experiences are studied from other world BIM adopters. Review of literatures was very time consumingand also budget constraints was another problem. A literature study's strength is its availability for further research.

3.4Data Sampling

Since the number of public construction projects in Dire Dawa is small, all population size is taken for thesis study. The selection of the participants is one of the initial steps taken towards data gathering and sampling. Determining the proper sample size for this research was the next step. Englander argues that small sample sizes, probably no more than 10 participants, are most suitable for this type of research while the minimum number of participants is limited to three, becauselarge samples can become unmanageable. (Englander, 2012).Patricia A. Adler, and Peter Adler also Suggestthataminimum sample of 12. This number gives the experience ofplanning and structuring interviews, conducting and partially transcribing these, and generating quotes for the papers. More than this number, itseems to be impractical within customary time and budget constraints.

Therefore, in this study a total of twenty two (22) construction firm participants were selected for data gathering purposebut fourteen (14) participants were voluntary and interviewed. All respondents have made a face to face Interview at their place of employment offices.

3.5 Interviews

The aim of this research is to assess the common problems in the Dire Dawa public construction projects and also to assess the perception of stakeholders (Consultants and Contractors) of the public projects towards BIM. Dire Dawa public projects Consultant side professionals and Contractor side professionals are the data source for this study.

The questions in the Interviews focused primarily on construction problems in respondents' projects and understanding respondents' awareness towards BIM: familiarity, general knowledge level and its specific application to projects, existing work practices and experience.

The aim of the research was to understand the Dire Dawa public constructions common problems through interviews, determining the professional's perceptions of BIM and finally showing the potential applicability of BIM in solving the identified problems by thematic review of the Literature.

Developing interview questions to start the interview was another important step in the research. The questions developed for this research were partly open ended semi-structured questions with the goal of starting the conversation where the interviewee tells about the problems they commonly face in their projects. There are also partlyclosed ended structured questions to know perceptions of professionals towards BIM.

Open-ended questions are questions to which there is no one definite answer. They are designed to enable the respondent to answer in full, to reply in whatever form, with whatever content and to whatever extent the respondent wishes (Fellows &Liu, 2008).They may be a good way to break the ice with a survey, giving respondents an opportunity to answer in their own words (Duval, 2005).Despite their usefulness in yielding quotable material, the responses to open-ended questions are more difficult to catalogue and interpret (Fink, 1995).

According to Creswell (2013) the problems for which the understanding of individuals' work experience and phenomena is essential, are the best suited problems for Qualitative research. Therefore, Qualitative research methodology is considered the best approach for this type of research.

After obtaining permission from the Dire Dawa City Administration Mayor's office, Arrangements were made to interview the participants in person. The data was collected through semi-structured and structured interviews with the research participants. In all cases the interviews were taken by taking notes. The participants were also given a chance to review the replies taken on notes to ensure that they were comfortable with the information they had provided and provide feedback in cases they may view as incorrectly written notes. Each interview was assigned a code to avoid the use of individual identifiers throughout the study .

Once the data is gathered, Hycner's (1999) explication process was followed.

1. Bracketing self-presupposition: No position is taken for or against researchers' presupposition. Researchers' theoretical concept, meanings and interpretations are to be avoided from entering the unique world of participant. It is basically bracketing researcher's personal views and Preconceptions.

2. Delineating units of meaning: in this stage, the data and statements informative to the researched phenomena were extracted. While bracketing self-suppositions, considerable amount of judgment calls were made while units of similar meanings were extracted

3. Form themes by clustering of units of meaning: Grouping the units of meanings formed cluster of themes. The meanings of clusters were further interrogated to establish central themes which in turn, expressed the core of these clusters.

4. Summarize each interview individually and validate the information by the informant: A validity check was conducted by returning to the informants to make sure the fundamental nature of interview was captured accurately and fully.

5. In this stage, general themes for all the interviews were included in a composite summary.

3.6 Data analysis

This process is conducted to get in-depth understanding of construction problems in Dire Dawa public projects; and also the awareness of Dire Dawa public construction representative professionals towards BIM. The further analysis of this data will result in the identification of the problems that BIM technology can solve.

All interview records and notes for specific participants were clearly labeled and dated using the coding scheme previously identified. Once data collection was done, all recorded interviews were transcribed thoroughly before any analysis. All transcriptions were then returned to the participants for validation to make sure nothing is taken out of context in the written notes or expressed different than participant's original view and thoughts in order to capture the pure phenomena. Soon after the participant validation process, the data analysis was conducted via putting all general and unique themes into a composite summary.

4. RESULT AND DISCUSSION

4.1 Overview of Results.

The aim of this research is to assess the common problems in the Dire Dawa public construction projects and determining problems that could be solved using BIM by thematic review of the literature; & also to assess the perception of stakeholders (Consultants and Contractors) of the Dire Dawa public projects towards BIM. Dire Dawa public projects Consultant side professionals and Contractor side professionals are the data source for this study.

A series of face-to-face interviews was conducted from October 07 to October 26 2017. The interviewees were 14 professionals from 14 firms and institutions, which included eight contractors and six consultancy firms. They are representatives from the projects.

Interviews were intended to assess the common construction problems that exist in Dire Dawa public construction projects, solutions given by the professionals, and finally their perception towards BIM.

4.1.1Demographics

When respondents were asked about their role within the company,majority of them were found site supervisors (42.9%), (28.6%) were site engineers, (14.3%) were office engineers, (7.1%) were construction engineers, and (7.1%) were project managers.

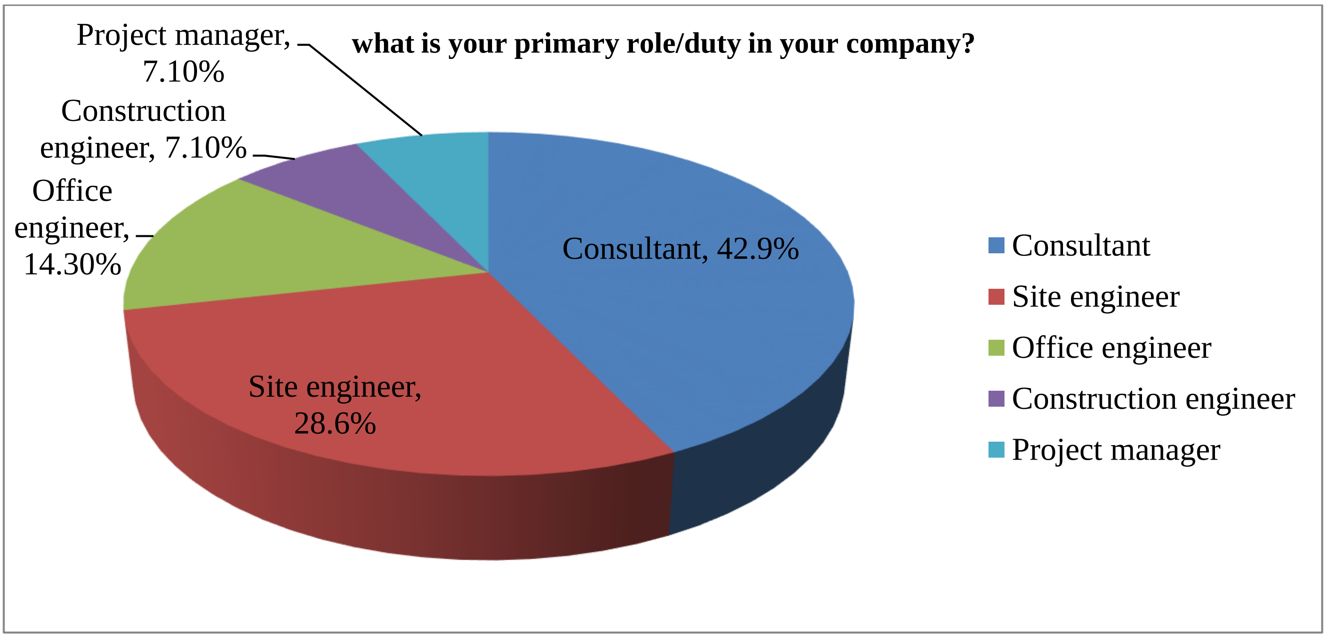


Figure12: Respondents role within their company

The figurebelow presents respondents ‘experience in construction firm. It is observed that majority of the respondents worked in companies which have been a part of the Ethiopian construction sector for

4-7 years (42.9%) and 8-10 years (28.6%). Very few respondents were form companies which had more than 10 years' experience (14.3%) and 0-3 years of experience (14.3%). These statistics indicate that the representative Respondents are employed in companies which have been in a construction sector for more than 5 years and have greater relevance of exposure to the research interview issues

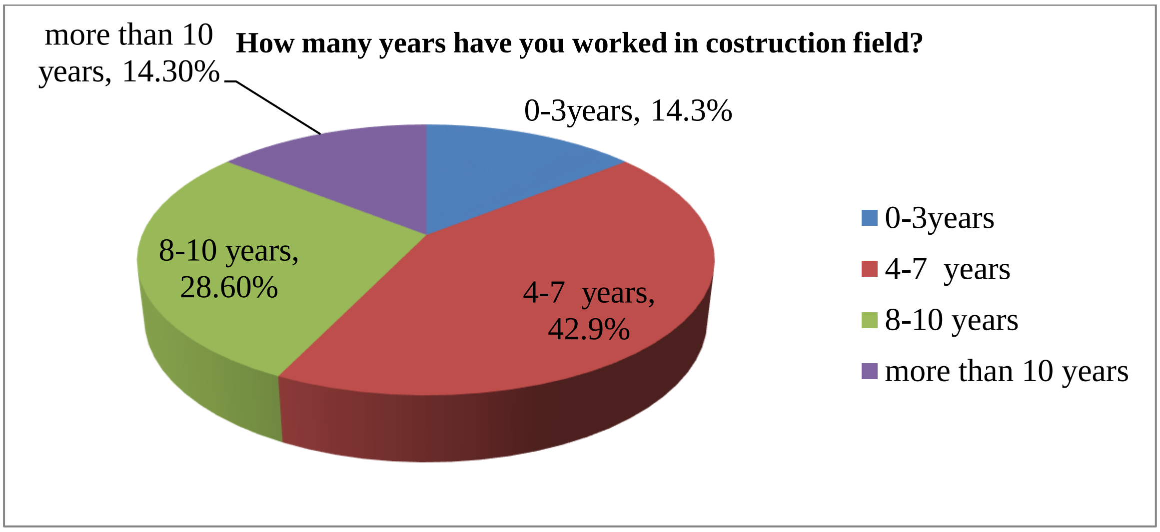


Figure13: Respondents construction work experience

The figure below presents the type of construction firm of respondents involved in. It is observed that the majority of respondents were found to be employed in the Contactor (field) department (57.1%) and the percentage of respondents in design and supervision (consulting) department is (42.9%). A more or less equal distribution of employees between the two sectors will facilitate the complete and unbiased views of professionals in Dire Dawa public construction projects during data collection.

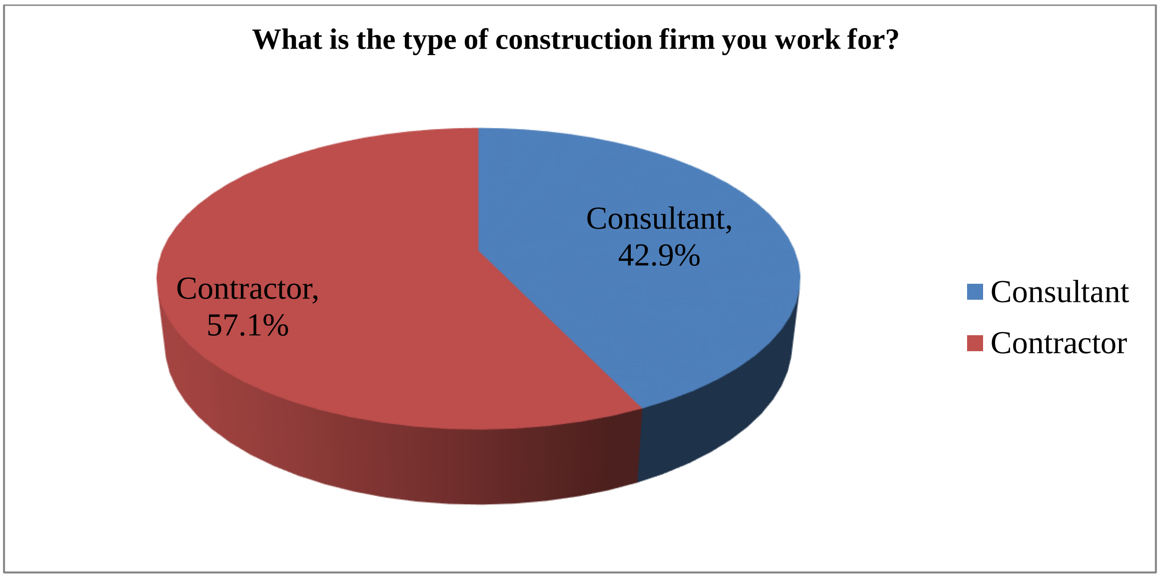


Table 14: Type of Construction Firm respondents engaged in

The figure below presents the type of construction the construction firms engaged in. It is observed that majority of the respondents were involved in construction of buildings (71.4%), and (28.6%) of them are involved in Road construction. Since the BIM is largely applicable to buildings construction, representation by a majority of the Respondents in this section presents a greater advantage to the Research.

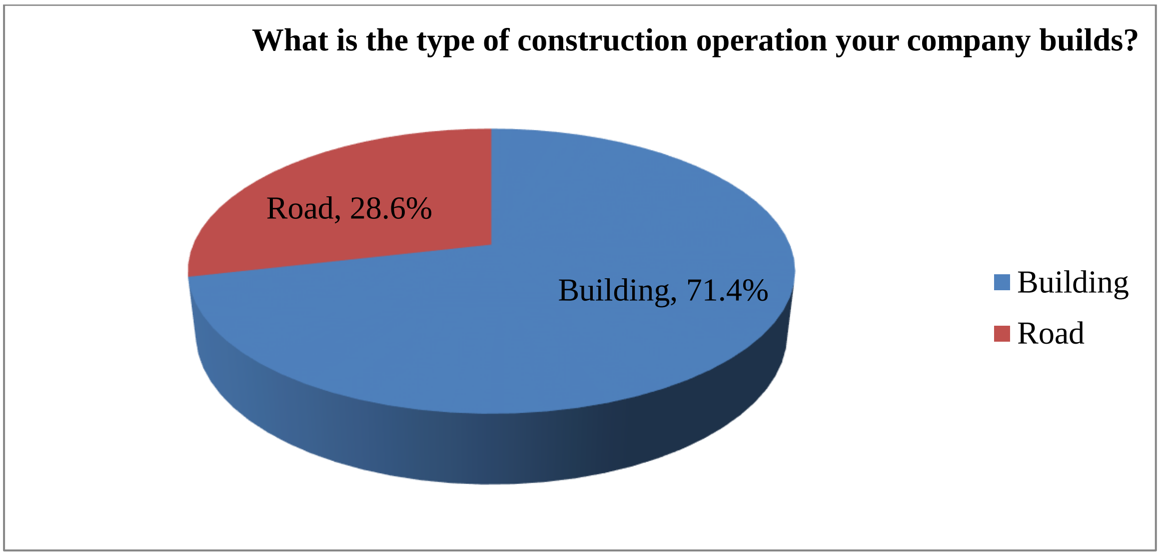


Figure15: Type of construction operation respondents 'company involved in

4.1.1 Construction problems in Dire Dawa public construction projects.

When the representative professionals were asked about the common construction problems in their projects, some of problems are common to many of the projects. However, there are also problems which are unique to a project. These views are observed from the following respondents' statements.

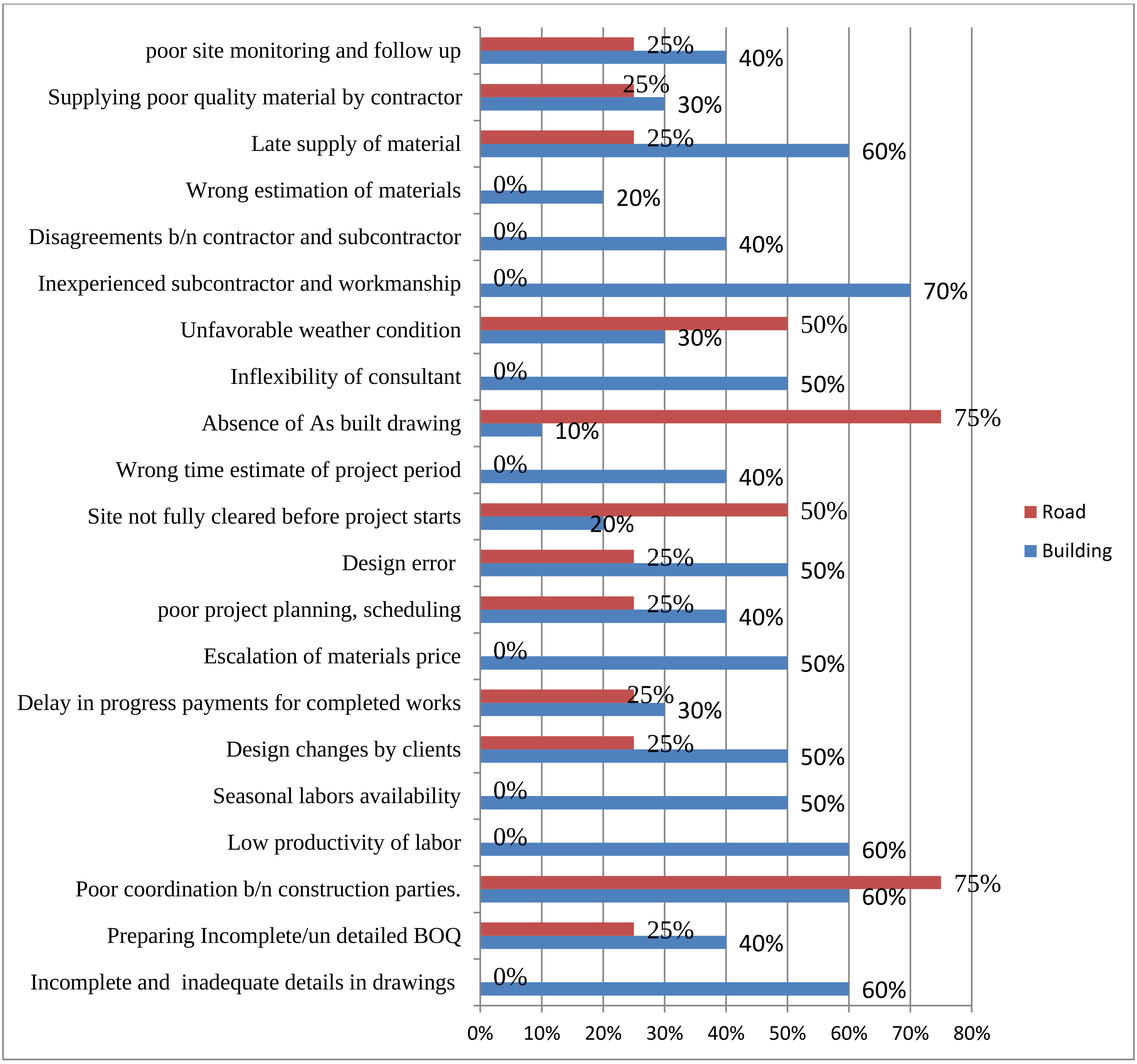


Figure16: Construction problems in respondents' construction projects

4.1.2 Awareness of Respondents towards BIM.

The figure shown below illustrates respondents' BIM awareness. It can be seen that 14.3% of respondents are aware of BIM. And majority of respondents 85.7%of respondents are not aware of BIM concept. This indicates a very low level of awareness of the BIM amongst the construction stakeholders of Dire Dawa public construction projects.

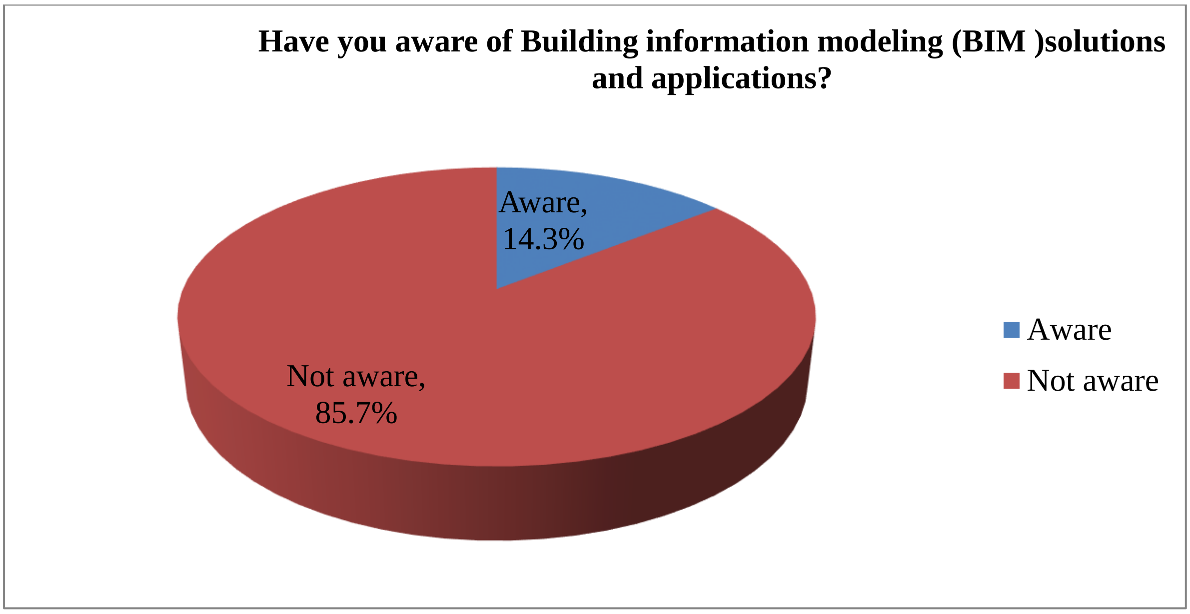


Figure17: Awareness of respondents towards BIM

The figure below presents the percentage of construction firms that are aware of BIM. It is showed that 20% of building construction firm respondents stated that they are aware of BIM, however all (100%) road construction firm respondents are not aware of BIM.

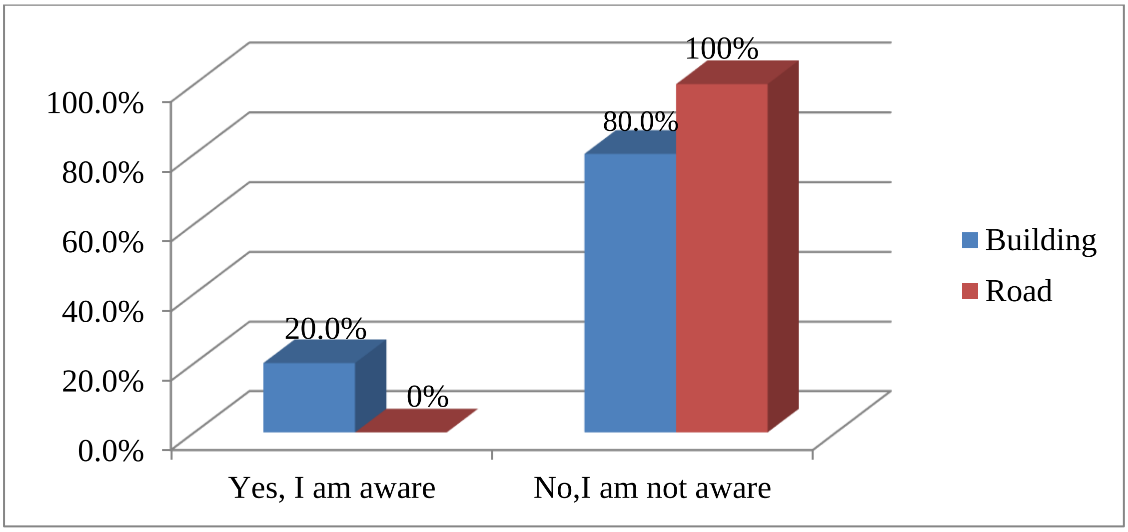


Figure 18: Awareness of respondents towards BIM in different construction firms

4.1.3Understanding on BIM

Although 14.3% of respondents suggested that they were aware of BIM, with a view to addressing the research's objectives, further questions sought to reveal the exact level of understanding that the respondents had of BIM concepts. The Interview therefore put forward to determine the respondent's own definition in order to gauge how they understand BIM.

7.1% of respondentsstated that BIM as advanced software that increase visualization of a building to be constructed in a conceptual 3D-model early before construction commences. Other 7.1% of respondents described BIM as it is software like ArchiCAD. The rest85.7% of respondentssaid that they don't know and unfamiliar with the concept of BIM. Moreover,

These highlight the fact that almost all professionals within the public projects have a complete lack of understanding in regards to BIM.

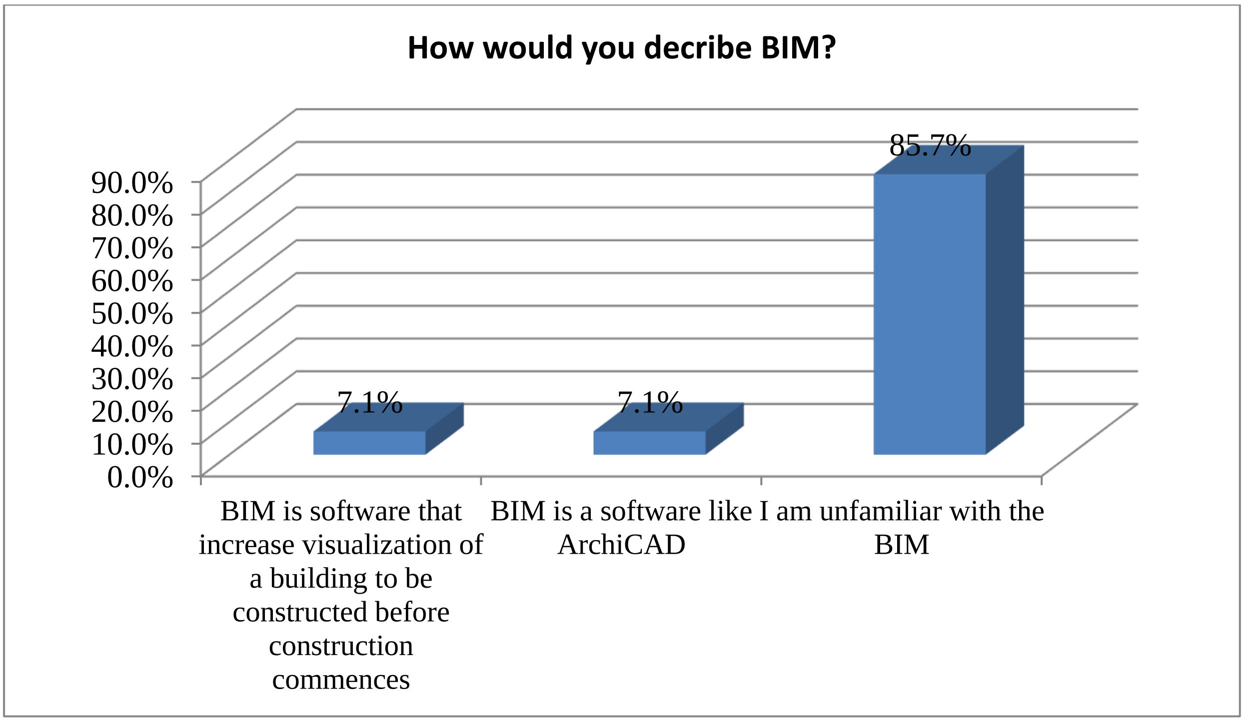


Figure19: Understanding of respondents about BIM concept

4.1.4 Usage of BIM in public projects by respondents

The figure below presents the responses received from respondents based on the amount BIM usage in their projects. From the interview response, all of the respondents (100%) have not yet worked on any projects using BIM. This percent of BIM usage was a very small percentile of the total respondents when compared to the AEC industry for developed countries such as the North America, Canada, New Zealand, and UK.

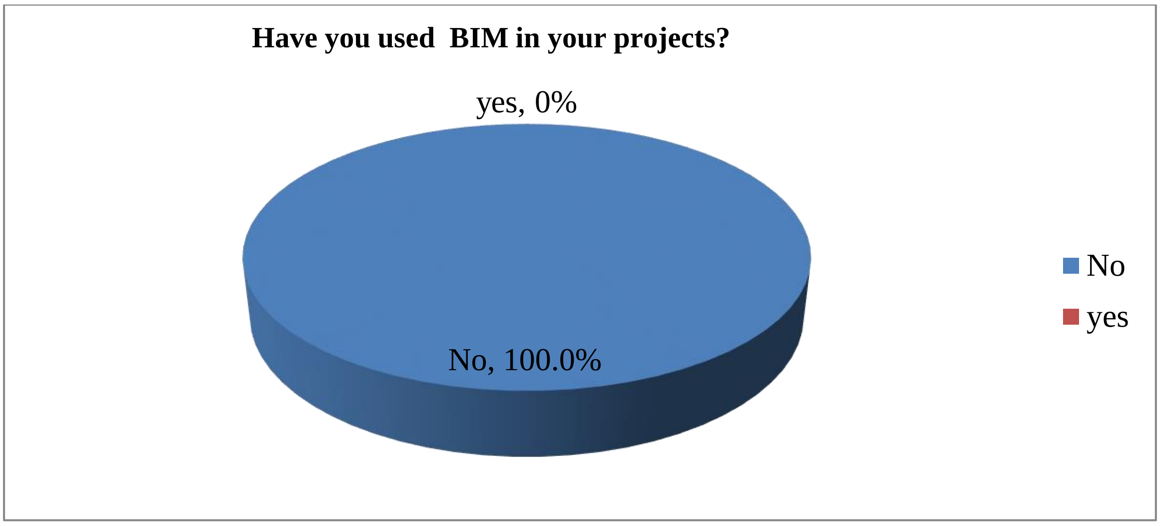


Figure20:Usage of BIM in respondent's organization

4.1.5 Level of BIM Knowledge among Construction stakeholders as per the respondents.

From the results of respondents as shown in figure below 14.3% of respondents believed that the current knowledge level about BIM among people in their projects is low. 85.7% of respondents stated that they are not familiar with BIM.

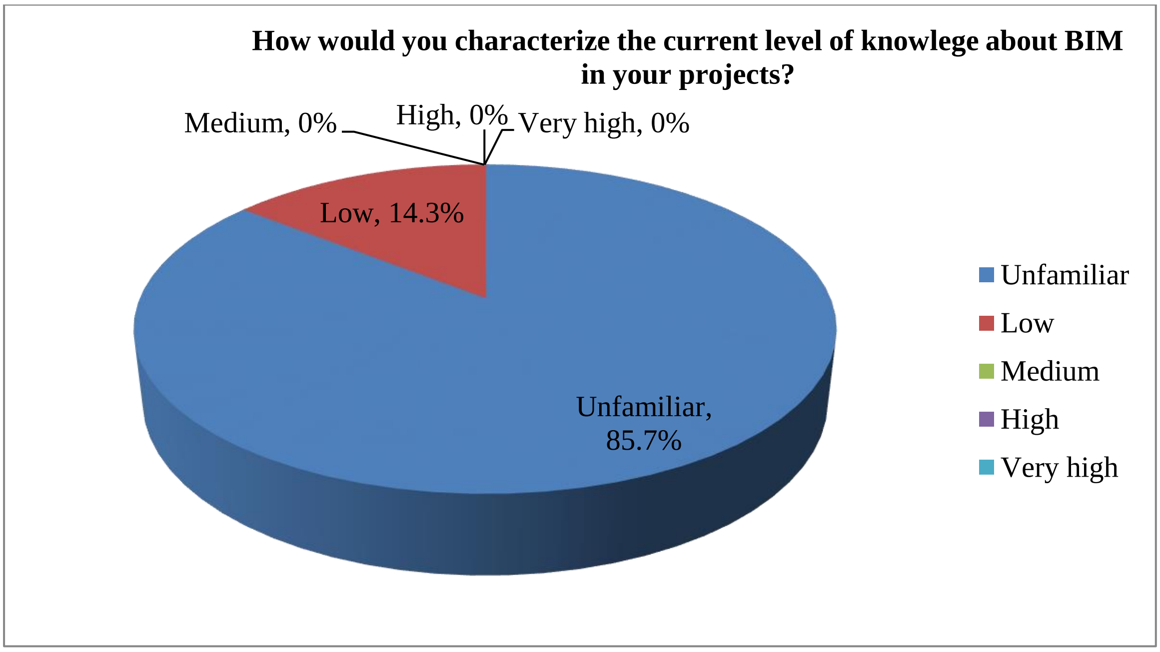


Figure21: current level of knowledge about BIM in respondents' projects

The figure below presents the level of knowledge of BIM in different construction firms. From the results of the interview it is identified that 80% of building firms are unfamiliar with BIM, and 20% of construction firms have low knowledge of BIM. On the other hand road construction firms' respondents identified that 100% of the road construction firms are unfamiliar with BIM

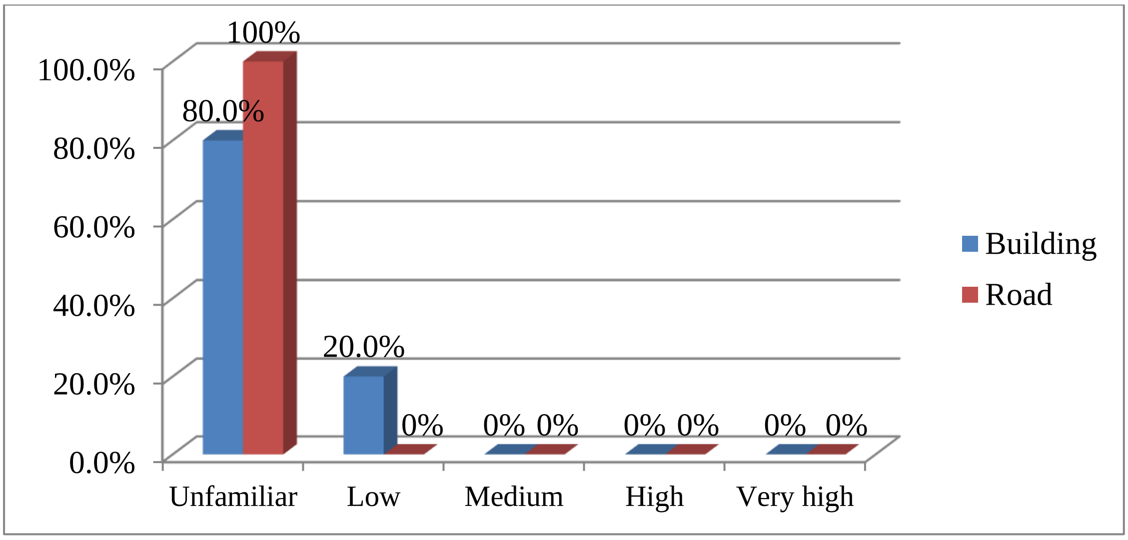


Figure22: current level of knowledge about BIM in different Construction firms

4.1.6 Construction Firms planning to use BIM in1-2 years' time

The figure below summarizes the responses received from respondents on the plan of their Firms to use BIM in their projects in 1-2 years' time. It is clear that all respondents are not using BIM in their projects and the respondents were further asked about the plan of their Firm to use in the coming 1-2 years. 21.4%of the respondents answered that they are not sure of it and 78.6% of the respondents said that there is no plan to use BIM in their project in the coming 1-2years.These highlight the fact that all construction firms (players) have a complete lack of the potential benefits and applicability BIM to their projects.

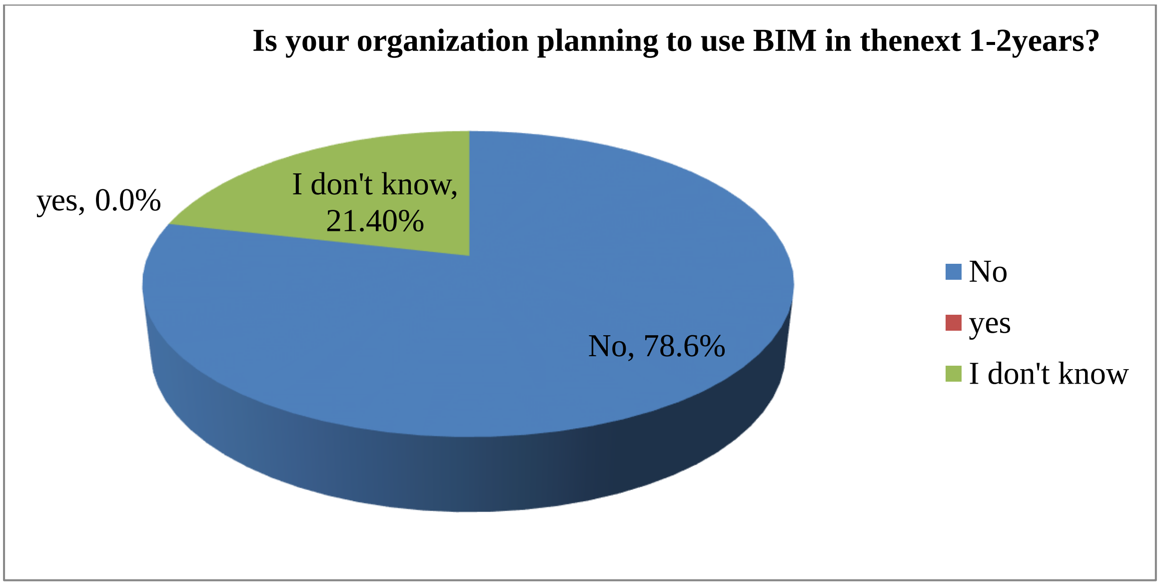


Figure23:plan of respondents' organization to use BIM in the next 1-2 years

The figure below presents plan of different construction firms to use BIM in the next 1-2 years. From the results of the interview it is identified that 70% of building firms have no plan to use BIM, and 30% of respondents stated that they don't know the plan of their Firm. On the other hand all road construction firms' respondents identified that 100% of the road construction firms have no plan to use BIM.

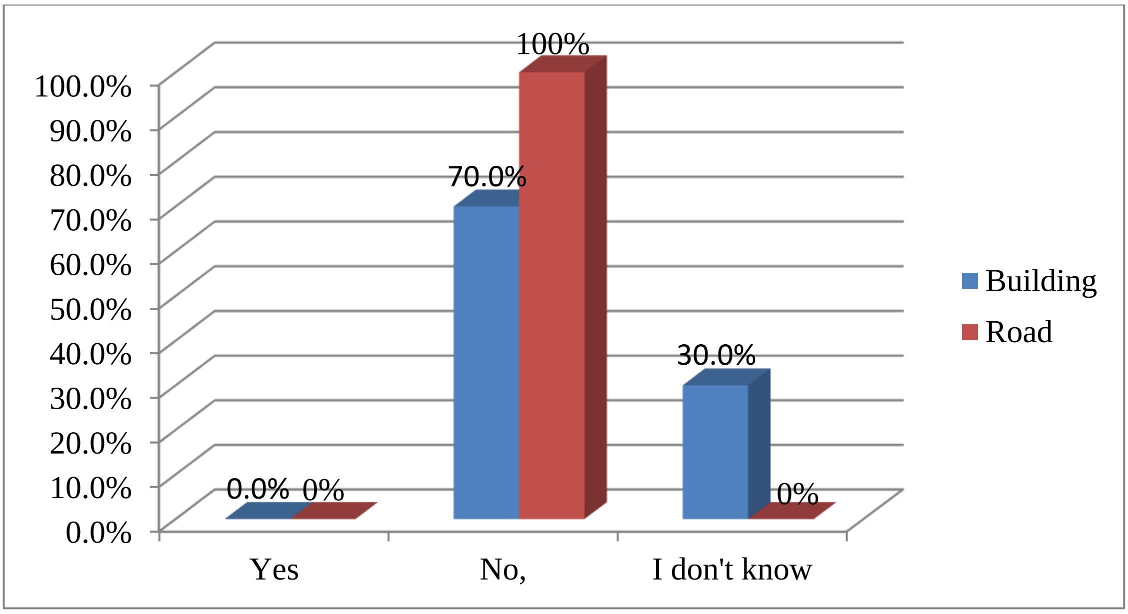


Figure24: plan of different construction firms to use BIM in the next 1-2 years

Summary of awareness level and usage of BIM in Dire Dawa public construction projects.

The figure below presents the summary of awareness and usage level of BIM in Dire Dawa public construction projects. From the results of the interview it is identified that 85.7% of building firms are not aware of BIM while 14.3% of building firms stated that they are aware of BIM but haven't used in their Firms. On the other hand all road construction firms' respondents (100%)stated that they are not aware of BIM.

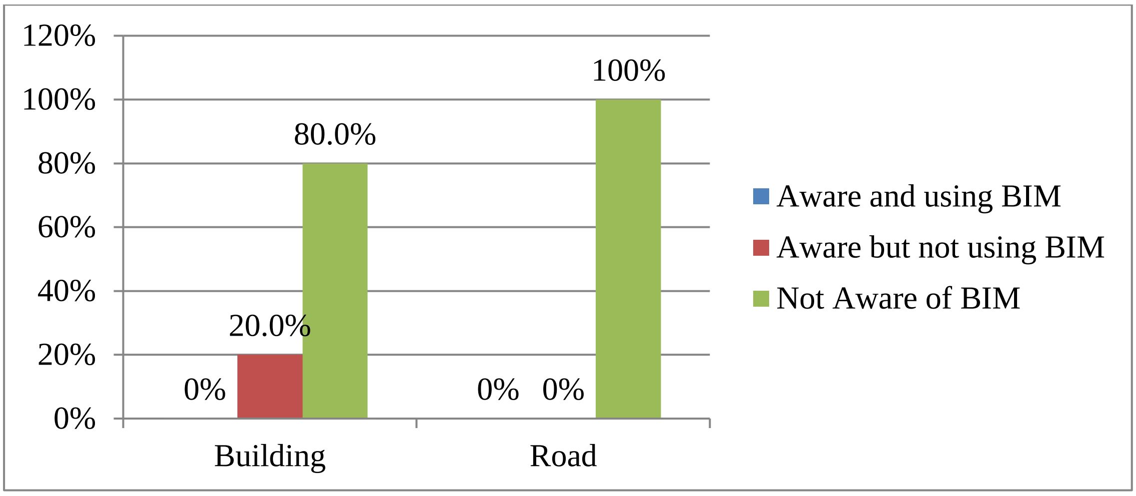


Figure25: Awareness and usage of BIM in DD public construction projects.

4.2Data Analysis and Discussion

This chapter analyses the responses obtained from the Interviews. In order to fully explore the findings of our results, it will be necessary to study the cross relationship between each of the questions and answers, whilst also being mindful of relating these results with the knowledge gained from the literature review. For the purpose of analysis, this study has been divided into the following sections: Construction problems and Respondents proposed solutions to construction by respondents, BIM knowledge Assessment in public construction projects of Dire Dawa town. The analysis seeks to determine construction problems in public projects, how public construction projects of Dire Dawa tapped the potential benefits of BIM to solve these problems and the awareness of public projects professionals towards BIM. Finally, having already identified the problems in the public projects and awareness of professionals towards BIM, the potential applicability of BIM which the professionals were not aware off will be analyzed. Finally the analysis will then put forward the necessary actions (recommendations) which need to be taken in order for the public construction projects to tap the benefits of BIM. A copy of the interview questions is enclosed in Appendix.

4.2.1. Construction problems

14 construction firms in Dire Dawa public projects were interviewed about the construction problems in their projects. From the interview of consultants/supervisors, and contractors common constructions problems are identified. Among the listed common problems are difficulties in financing project by contractors, escalation of material price, poor project planning, scheduling and resource management, delay in progress payment for completed works by clients, and lack of skilled professional in construction projects organization, unfavorable weather conditions, inexperienced subcontractor and workmanship, reworks, design changes, inexperience of project staff, changing demands of clients, design errors, inadequate of material, late supply of material, disagreements between owner, contractor or subcontractor, slow decision making. These problems cause extension of construction durations and budget. Therefore, problems which can be solved with Building Information Modeling will be identified from the theme of Literature review.

Construction problems that exist in Dire Dawa public construction projects are shown in the figure below:

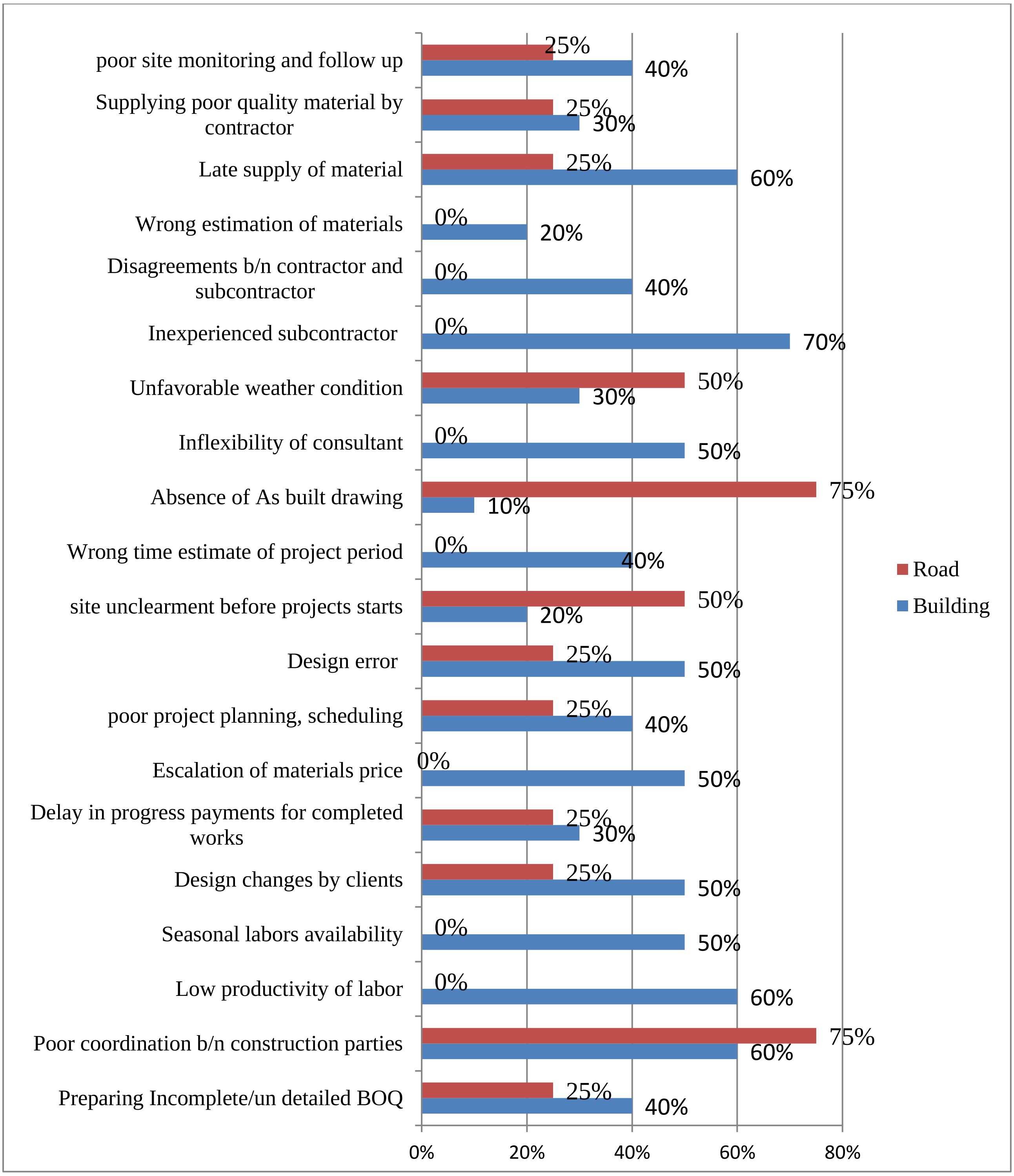
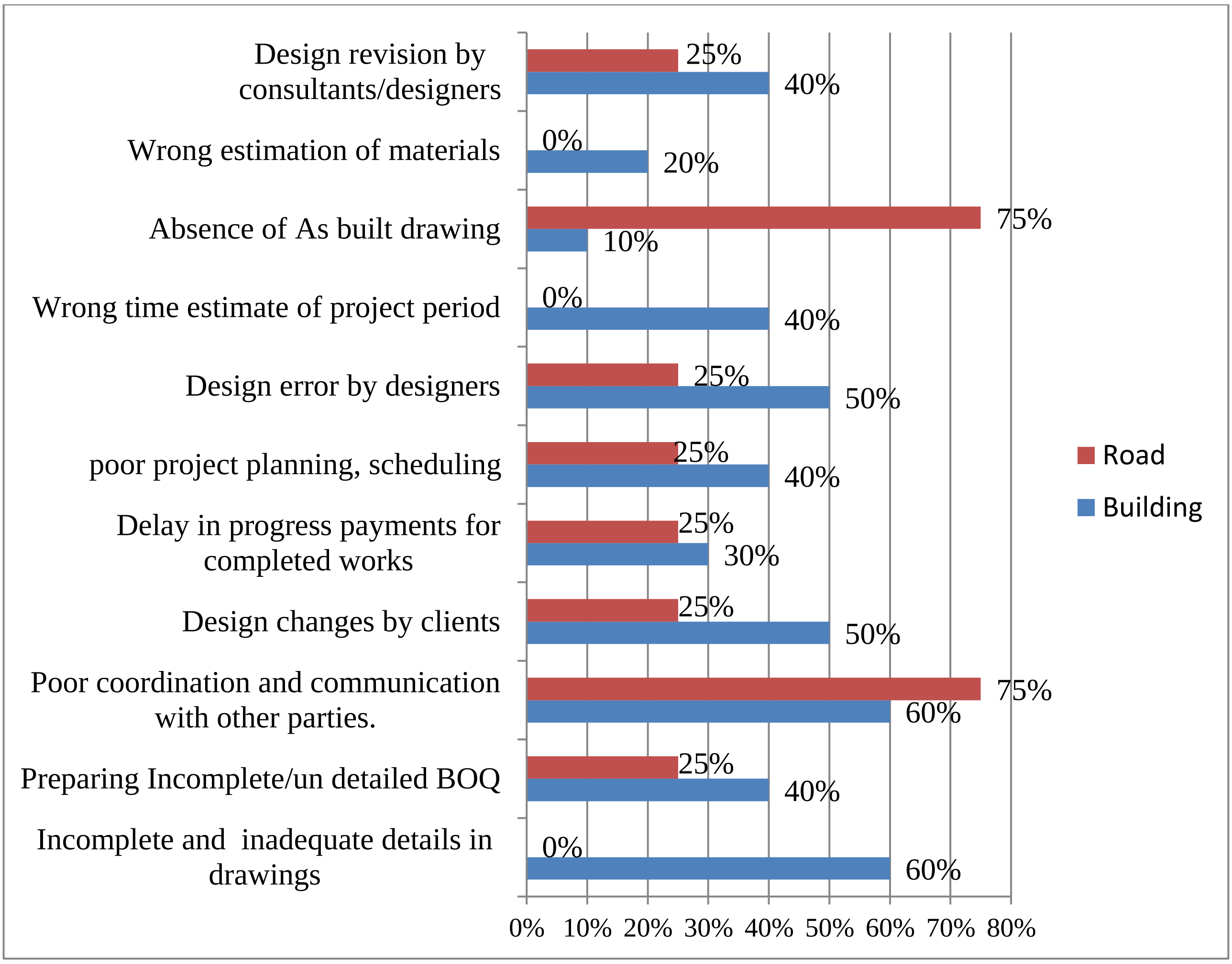


Figure26:Construction problems in Dire Dawa public construction projects from respondents

4.2.2 Construction problems that BIM can address

Construction problems may arise due to some reasons which are related with the design or they may arise when construction starts.21 construction problems are collected from the interview results. Now these construction problems will be identified and analyzed whether they can be solved with BIM technology or not from the concept developed in Literature.

From the common problems that are in Dire Dawa public construction projects, List of problems that BIM potentially would solve is determined. They are then will be discussed and related to the theme of literature reviews for their assertion by stating from the studies and experience early adopter and implementer countries. Identified construction problems BIM would potentially solve are shown in the figure below.



Figur27: Construction problems in Dire Dawa public construction projects that BIM could solve.

4.2.3. The potential Applicability of BIM in solving construction problems

Poor coordination & communication between construction parties

From the final identified construction problems through interview Poor coordination & communication between construction parties is prominent because 63.4% of interview respondents stated its existence in their projects. In the projects there are architect, office engineers (civil engineer), Site engineers, Sanitary engineers, construction managers, quantity surveyor, clients, consultants, and main contractor. The lack of coordination among construction parties from the beginning to the end is a major problem in the projects. This has resulted lack of integration of design information (2D drawings –architectural, structural, sanitary, mechanical), which leads to unnecessary time variations and design changes in the construction projects.

Complete and coordinated design information is crucial for the construction professionals to construct complete and error-free facility. Coordination in the design process might be viewed as an activity to handle the uncertainty and to synchronize the flow of design information. It is also about synchronizing the collection processing, storage and transmission of information, which is essential for an effective design process.

To overcome this problem, more coordination among the team members is needed in order to improve the accuracy of design information and to avoid time delay. The great intelligence of BIM lays in the fact that it is able to collaborate building information, integrate a multidimensional approach to design, whilst also being able to combine all the life-cycle phases of a building/infrastructure in the form of a single digital virtual Model. Furthermore, BIM is able to cover planning and design (sustainability information, 3D, 4D, 5D and nD modeling), construction (construction management and coordination), operation and maintenance (retrofitting, energy simulations) and demolition (waste management, reuse and recycling,).(Eastman, 1999). Therefore, it can be concluded that the use of Building Information Modeling a valid solution for this problem.

Changing demands of clients

According to the Interview results, the other common problems of Dire Dawa public construction projects are the changing demands of clients. 42.9% of interview respondents stated its existence in their projects. But With the help of BIM technology, continuously changing demands of clients can be minimized. Clients usually define their demands for project at the briefing stage and designers try to satisfy clients by designing project that meets the demands of clients. However, when construction starts and clients see the project in real life, they sometimes happen to change their demands and decisions and in turn this leads to change in design with the traditional methods as can be seen from the results. This is because clients may not be technical people and they may not understand project from traditional methods (two dimensional paper based design). Literatures also states that Client involvement and client satisfaction are increased when using BIM. The client's involvement throughout a BIM project will translate the client's value preposition properly (Hattab,Hamzeh, 2013). Therefore, if BIM technology that includes intelligent object oriented design is used, 3D visualization may enable clients to see whole aspect in detail and it helps to imagine what will be the end product (Azhar, 2011). Therefore, it can be concluded that the use of Building Information Modeling approach may be a valid solution for this problem.

Collision detection (design error)

Collision detection is other problem that existed in these projects. From the interview results 42.9% respondents stated its existence in their projects. In Dire Dawa public construction projects, traditional methods (2D paper based drawings) are used as a means of information Delivery system. Respondents reported that when they came across to design errors, they mostly send a letter to consulting company for a revised drawing. Then the consulting company will revise the drawing and send them back and the revised drawing will be used as a new working drawing. This is the trend they are following.

The use of 3D parametric modeling tools in BIM also improves the clarity of representation of the design intent and consistent drawings production. Mismatch or internal contradictions in the content of any individual document or related sets of documents are eliminated and the increase in clarity and consistency leads to a much more efficient design production process within the organizations and improves the interaction and communication between parties in the construction projects (Kaner et al., 2007)

Therefore, by the potential application of BIM collision problems can be prevented since they are detected before commencement of construction, at an early stage (Rajendran and Clark, 2011). Literatures Very that With BIM technology, architects, structural engineers and MEP engineers work on the same model so clashes between activities, conflicts in the plan and inefficiencies in design can be detected before construction starts at site so that clashes can be modified and errors can be corrected before construction starts. Also, extension of project duration and extra cost can be minimized (Ashcraft, 2007).

Poor project planning, scheduling and wrong time estimation

From the identified construction problems Poor project planning, scheduling is stated by 35% of respondents and wrong time estimation is stated by 28.6% of respondents. The construction planning includes scheduling and sequencing of the model to coordinate virtual construction in time and space and schedule of the construction progress can be integrated to a virtual construction. Building can be linked to project schedule and construction schedule can be synchronized. Also, it allows users to simulate the construction process and show the virtual view of the building (Hergünsel, 2011).

4D BIM models allow for demonstration of how the construction project would affect traffic flows, access and entrance, public transport, and storage of materials on site, and the scheduling of machinery and personnel. With the application of 4D BIM, the objects in a building information model are linked to time plan. The linkage to time plan makes it possible to graphically visualize the objects schedule and users can simulate the building site and construction at any point in time. This type of simulation provides considerable insight and allows for early detection of planning errors. Instead of realizing planning mistakes later on in the construction phase, and having to resolve problems on site which can be very costly, mistakes can be eliminated already in the design phase (Eastman,et al., 2008).Therefore wrong time estimate and poor construction planning can be avoid with the potential applicability of BIM.

Preparing Incomplete/un detailed BOQ, wrong quantity estimation

From the identified construction problems Preparing Incomplete/un detailed BOQ is stated by 42.9% of respondents and wrong quantity estimation is stated by 14.3% of respondents. Since materials are ordered according to calculated amounts, if material estimations are done correctly and ordered on time, these problems are not faced. On the contrary, when wrong amounts are ordered, the project stops, then correct amounts are ordered, which causes delay in completion time.

Quantity takeoff and pricing are the two important parts of cost estimation. Cost estimation is a critical process which is time consuming since interpretation of the project, visualization, specification reading, calculation of quantities of materials, equipment and laborer required (Shen,Issa, 2010) because accurate bill of quantities should be obtained and estimations should be obtained over these quantities.

Depending on organizations, estimation methods can be different. Estimators calculate only the direct cost which includes materials, workmanship and equipment cost. In addition to that, in some cases cost of subcontractor can be added on top of this direct cost calculation. Overhead costs are calculated many times over again and sometimes contractors add overhead and profit on the direct cost. Therefore, tender price includes both direct and indirect costs where risks, profit, cost of materials and cost of labor are included in tender price.

BIM has cost estimating features and bill of quantities can be extracted automatically. At the beginning, cost can be assessed and more detailed cost estimate can be obtained at a more detailed model (Grilo, Goncalves, 2010). Since quantities extracted from BIM model are accurate, BIM would produce a more reliable and accurate cost estimate than traditional methods and when any change occurs in model, faster cost feedback can be obtained on changes in design (Eastman et al., 2011). So that productivity of Estimator can be improved with BIM.

In addition to that when 4D BIM model is combined with cost, 5D BIM models can be produced and cost estimations can be obtained. Therefore, BIM helps to obtain more accurate and fast quantity takeoff, planning and scheduling can also be obtained with 4D BIM models and 5D BIM model can be used for cost estimations and different cost alternatives can be obtained.

Design revision by consultants/designers

From the identified construction problems Design revision by consultants/designers, are stated by 28.6% of respondents. In usage AutoCAD for producing project drawings, plans, views, and sections is drawn separately and if any design changes occur, these changes need to be corrected on each drawing one by one. This process is causing waste of time and increases the possibility of error in drawings leading to frequent design revisions in Dire Dawa public construction projects.

However, when BIM soft wares are used to produce project drawings, plans can be produced and views, sections, 3D views, and elevations can be obtained automatically. In addition, when any change is done in any view, it will be automatically changed from all relevant drawings and realistic renderings can also be generated. Therefore, BIM technology enables the company to deliver construction documents with more 3D views, sections, schedules, and realistic renderings. BIM increases efficiency, especially for construction documentation (Jiang, 2011).

Comparing BIM with traditional methods, there is no risk of forgetting to update changes in design because any change in any view is automatically updated in all relevant plans, views, sections and elevations. For example, lines are used to draw wall in CAD and if width, height or length of wall is needed to be changed, it should be changed manually and all other related parameters should be changed one by one that increases the risk of forgetting to update changes. However, BIM facilitates design change process because if any design changes occur in objects, it is automatically updated in other related objects therefore it reduces errors and omissions that may occur in CAD design. Also, 3D view, side views, plans and sections can be generated automatically from the design model.

Absence of previous as built drawings

From the identified construction problems Absence of previous as built drawings, are stated by 7.1% of respondents. As Respondents stated since there is no as built drawing of previously existing utility lines, in some of the projects it was difficult task to them to know what utility lines exist at the construction site, before commencement of the project. They usually discover them in the middle of their work. This problem is an existing problem, but from now they are planning to reduce it by strengthening their communication with other co working parties.

Literatures also support that BIM is object based, parametric modeling that collaborate building information, integrate a multidimensional approach to design, whilst also being able to combine all the life-cycle phases of a building in the form of a single digital virtual building. BIM is therefore able to cover planning and design (sustainability information, 3D, 4D, 5D and nDmodeling), construction (construction management and coordination), operation and maintenance (retrofitting, energy simulations) and demolition (waste management, reuse and recycling,). This therefore allows BIM to reduce problems allied to waste in the construction industry (Eastman, 1999).

If BIM is used, all parties are expected to work on the same model as mentioned above paragraphs and if there is any change, the change can be modified automatically through the BIM software. Solution is to use BIM technology so that coordination between parties is expected be improved since all parties work on the same model. The client satisfaction is expected to be increase by using visualization at the beginning of project. Design, collaboration, quantity, planning errors happening are potentially will be alleviated by the integration of BIM in Dire Dawa public projects.

4.2.4 Awareness of public Construction professionals towards BIM

According to this research finding 85.7% of Respondents were unaware of BIM; and 14.3% of Respondents were aware of BIM. But, when looking within the minority of respondents who claimed to be aware of BIM, it is evident that even within the group of people who are aware of BIM there is a lack of understanding about its concepts. The findings thus suggest that the respondents suffered from a lack of knowledge and skills sets in regards to BIM. It is therefore possible to conclude that lack of knowledge of BIM is one barrier preventing the usage of BIM in the Dire Dawa public construction projects.. Since construction Firm professionals are unaware of BIM’s great potential, they become uninspired to seek further information.

Literatures also assert that Lack BIM awareness is a barrier to the potential benefits which BIM can offer. The finding of the research suggests that no public construction Firm is currently the innovative technology and process called BIM in their projects. In support of the results of the study, the literature review also provided further evidence of BIM's wide ranging potential. Gerber (2011) and Teicholz (2013) also made reference to the most important uses of BIM; this is shown below in table 2.

When comparing the evidence which highlights the extensive benefits of BIM from the literature review to interview results of the study, it is clear that respondents are unaware of scope of BIM's benefits.

It is realized that most of respondents did not use BIM rather they are using traditional 2D CAD based delivery processes. The inefficiencies of these processes include: being paper based, multiple documents, manually produced and coordinated, excessive checking, prone to human error, costly and time consuming and multiple applications. The aim of the research is to benefit the public construction projects of Dire Dawa through creation of awareness and motivating them use BIM. Literatures also show that many construction firms encountered problems inherited with CAD design complexity and drafting errors as identified by Kaner et al. (2007), which led to low productivity, time delay, waste, and over budget. By understanding the BIM benefits, the construction firms' could possibly strategize their action plan for BIM implementation to suit their needs.

Although 14.28%of the respondents stated that they are aware of BIM but it is found that they did not clearly understand it. Because they couldn't describe the concept of BIM correctly as well as they have not use BIM application tools yet. Not only these 21.4% of the respondents stated that the awareness of BIM in their projects among professional is Low, while the rest 78.6% of respondents stated that BIM is totally a new concept that none of their project professional knows. Therefore it can be concluded that the awareness of BIM process and technology is very low in the public construction industry of Dire Dawa.

The table as shown in describes the distribution of respondents based on their description of the concept of BIM. Responses to the open ended question requiring the description of the concept of BIM showed that only 92.86% of the respondents gave incorrect responses to the description of the concept of BIM, while 7.14% of the respondents gave incomplete but a partial response to the concept of BIM. Thus, the data indicates the lack of understanding of the concept of BIM amongst respondents who claimed to be aware, and as such, indicates a very low level of the knowledge of BIM in Dire Dawa public projects.

4.2.5. Future Construction firm's plan to use BIM

Moreover 78.6% of respondents have stated that even in the coming 1-2 years there is no plan of using BIM to their project by their company, and other respondents (21.4%) stated they are not sure about their projects future plan. This indicates that the prevailing innovation total boosts the construction projects' productivity across the globe is not taken into account in Dire Dawa public projects even in Ethiopia. From the literatures as the experiences of early adopter countries indicates lack of awareness and knowledge of BIM is the biggest challenge in its adoption and implementation. This previous studies of the literatures also converges to the findings of this research.

4.2.6 Summary of awareness level and usage of BIM in Dire Dawa public construction projects.

The figure below presents the summary of awareness and usage level of BIM in Dire Dawa public construction projects. From the results of the interview it is identified that 80% of building firms are not aware of BIM while 20% of building firms stated that they are aware of BIM but haven't used in their Firms. On the other hand all road construction firms' respondents (100%) stated that they are not aware of BIM.

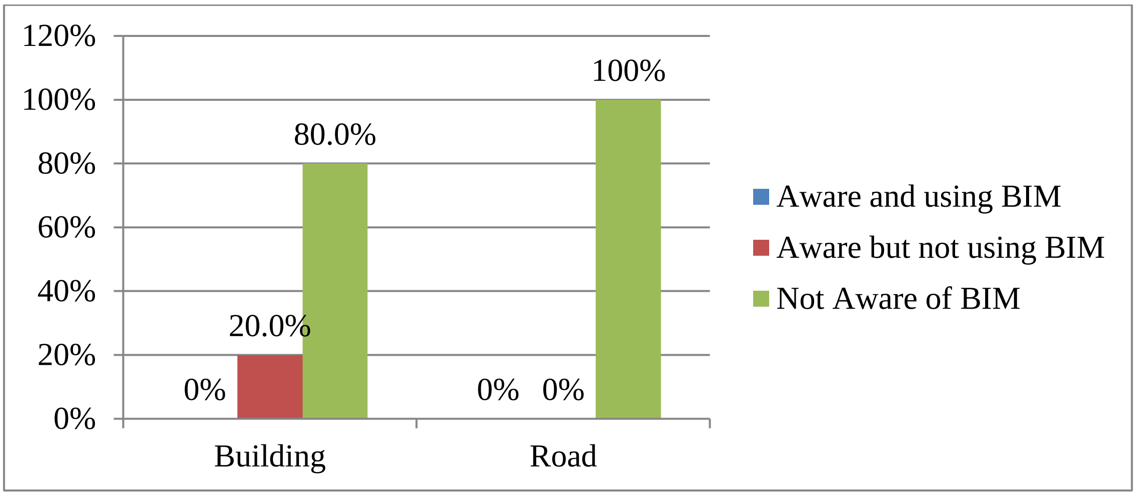


Figure28: Awareness and usage of BIM in DD public construction projects.

From the literatures as the experiences of early adopter countries indicates lack of awareness and knowledge of BIM is the biggest challenge in its adoption and implementation. This previous studies of the literatures also converges to the findings of this research. Moreover the awareness of Dire Dawa public construction projects professionals towards BIM is identified to be 14.3% . From the building firm,20% of the building respondents are aware of BIM, and from road construction firm, 100% of road construction firm respondents are not aware of BIM .Regarding the usage of BIM ,all (100%) of public construction firms are not using BIM. This shows that there is very low level of BIM awareness in Dire Dawa public construction projects.

Chapter 5-CASE STUDY PROJECT

Figure29: Rear-Right 3D view of G+4 Apartment Building

5.1 Introduction

This case study is aimed at structural design of G+4 Apartment at Dire Dawa. In general structural design deals with the frame works of a building structure such as slabs, beams columns and footings.

5.2 Design basis and methodology

5.2.1 Codes and standards

The design of the buildings is in accordance with the Ethiopian Building Code Standard EBCS-1995, Euro code 2-1992.

5.2.2 Units

The following units have been used in the entire design and any values of length, force or stress will be converted to this system:

Length (meters)

Forces: KN (Kilo Newton)

Stresses: Mpa (N/mm2)

5.2.3 Software

Three Main soft wares have been used for this study:

Excel-2010

This spreed sheet program has been used:

- **i)** To perform analysis of the loadings on the slab.
- **ii)** To transfer loads from slab to the supporting beams
- **iii)** To design the columns, Footings after an analysis result is obtained from sap 2000 software.
- **iv)** To customize the SAP 2000 design outputs of the beams to meet the minimum and maximum requirements of the EBCS-1995.

SAP2000 14

This Program has been used to perform all the analysis of the fame structure for all possible loadings and combinations. The input is:

i) Material characteristics

ii) Geometry of the structure

iii) External loadings

Superimposed dead loads

Live loads

Earthquake loads

- The 3-D modeling of the structures geometry by means of SAP 2000 program allows the real behavior of the structural system.
- The result of the model is combined according to the EBCS loading combinations in order to obtain the design forces and stresses in the structure, and perform the structural design of each part of the buildings.

Revit architecture and SAP 2000

Revit architecture program is used in the preparation of Architectural (elevation views, 3-D views, sectional views, site plan, floor plans,) modeling .moreover a finished floor plan of the building is sent to SAP2000 for structural Analysis.

Revit Structure is used in preparation of structural Drawings (elevation views, 3-D frame skeleton views, floor beam layout plans.)

Revit structure also receives the SAP structurally approved file and updates the structural overall plan without any conflicting issues. Revit generally checks using interference checks, coordination checks, and whether there may be any mismatching in the overall designs (structural, Architectural, MEP)

There is a trend in the market for the analysis suppliers to move towards a one stop solution that is capable of providing the full range of analysis options (Autodesk, 2007). The selection of a broad and detailed single application will allows the full range of analysis challenges to be tackled directly without the need to keep updating the building information model between separate programs.

The Autodesk Revit Suite has a bi-directional link that grants the ability to easily transfer information with the most used structural analysis soft wares in the industry, such as RISA Floor and RISA 3D by RISA, ETABS and SAP2000 by CSI, and RAM Structural System by Bentley.

The Revit – SAP2000 Link

The exchange of Building Information Modeling (BIM) data between Revit structure and SAP2000 is shown in the Figure below. It addresses specifics pertaining to data exchange between Revit Structure and SAP2000.

Data exchange between CSiXRevit and SAP2000 supports four different workflows:

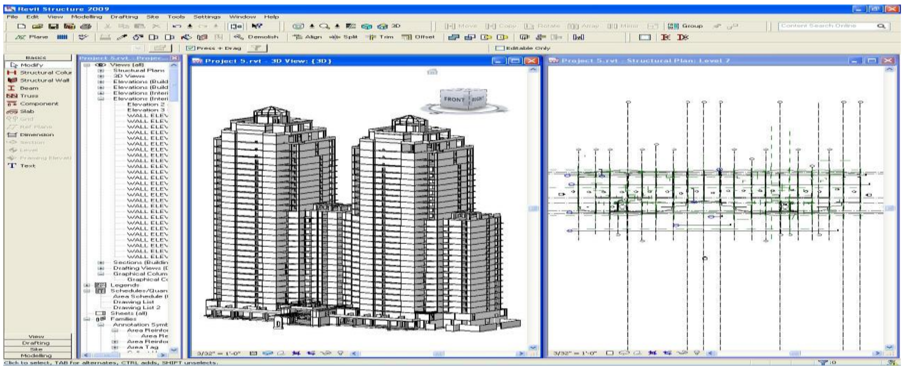
1) Exporting from Revit Structure to create a new SAP2000 model.

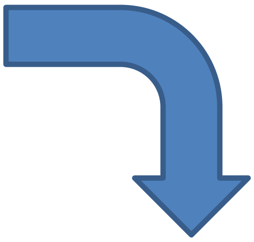
2) Exporting from Revit Structure to update an existing SAP2000 model.

3) Importing from SAP2000 to create a new Revit Structure project.

4) Importing from SAP2000 to update an existing Revit Structure project.

The flow of information is idealized in the schematic below:



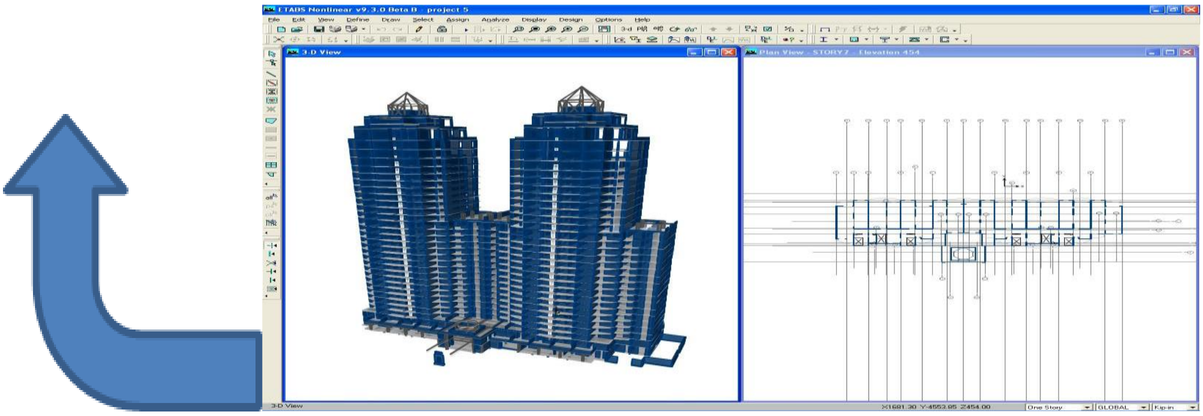


Revit® Structure

Export from Revit Structure to create a new SAP2000 model.

Export from Revit Structure to update an existing SAP model.

SAP2000



Export from Revit Structure to create a new SAP2000 model.

Export from Revit Structure to update an existing SAP2000 model.

Figure 30: The Exchange File tool for Revit and SAP 2000.

The link offers a variety of straightforward import and export options to maximize the control over the elements of the model that are transferred back and forth. An editable mapping file tool provides the ability to customize the link to support members and materials that are not included in the software, and a detailed log is constantly updated during every transfer to provide transparency and facilitate solving problems.

5.2.4 Design criteria

Materials

Concrete

For the main structural components of the buildings such as beams, slabs and stairs the concrete compressive strength at 28 days on 150mm in diameter cylinder samples is taken equal to 20Mpa.Equivalently, the 28 day crushing strength of 150mm cube is 25 Mpa. The concrete class according to EBCS-2 is thereforec-25.Where for Columns the compressive strength at 28 days crushing strength on 150mm cube is 30Mpa and therefore according to EBSCs -2 the concrete class is C-30.For other blinding layers(lean concrete) under footings, grade beams and slab resting on the ground the concrete quality is class C-5.

Reinforcing steel

- High tensile steel Grade 60 Fy=410Mpa

The yield strength for deformed reinforcing steel would be grade 60 with minimum yield strength of 410 Mpa.

Concrete cover to reinforcement:

- For Footings 50mm
- For beams, columns 25mm
- For suspended slabs and stair 20mm
- For slabs on hardcore 30mm

5.2.5 Geometry of structure

The building is G+4 consisting of reinforced concrete beams, columns and concrete solid slabs. The general structural system is composed of frames. Three dimensional modeling has been for the analysis of the frame. Below the different structural systems are in brief:

Floor Slab

180mm thick concrete solid slab system has been used for suspended floors.

Beams

Based on structural and architectural and architectural requirement different types of beam are selected. For beams supporting concrete slab 450mm*200mm and (depth x width) section have been selected.

Columns

450mm*450mm, 400mm*400mm, 350*350, and 300mm*300mm square column section were used (which can be referred from structural column drawing).

Foundation

Isolated footing types were used to transfer the super structural load to the foundation layer.

5.2.6 Loadings

The building is a G+4 Apartment Residence with 16.50m height and located in Dire Dawa, which is Seismic Zone-2 according to EBCS-8, hence both vertical and lateral loads were considered for the design.

Dead Load (DL)

Structural dead loads (beams, columns and slabs) and superimposed dead loads (Partition walls, finishing and cement screed) are taken according to EBCS-1.

Live loads (LL)

The live loads considered are taken from EBCS-1 according to the function of the rooms. For panels serving different function an average value has been taken

Earthquake loads (EQ)

Earthquake load is consistent with EBCS-8 1995. The site is zone -2 seismic zones. Therefore, a 0.05 acceleration ratio and site class B has been taken in designing the structure.

5.2.7. Load Combinations.

The load combination is used is used according to EBCS-1-1995.

Dead, Live and Earthquake loads design combinations.

ULTIMATE LIMIT STATE

I) 1.3DL+1.6LL

II) 0.75(1.3DL+1.6LL)+EQ

SERVICEABILITY LIMIT STATE

I) DL+LL

II) DL+LL+EQ

5.3. Soil Assumption

The bearing capacity of the foundation is assumed to be 280 KPa in proportioning the footings.

5.4 Slab design

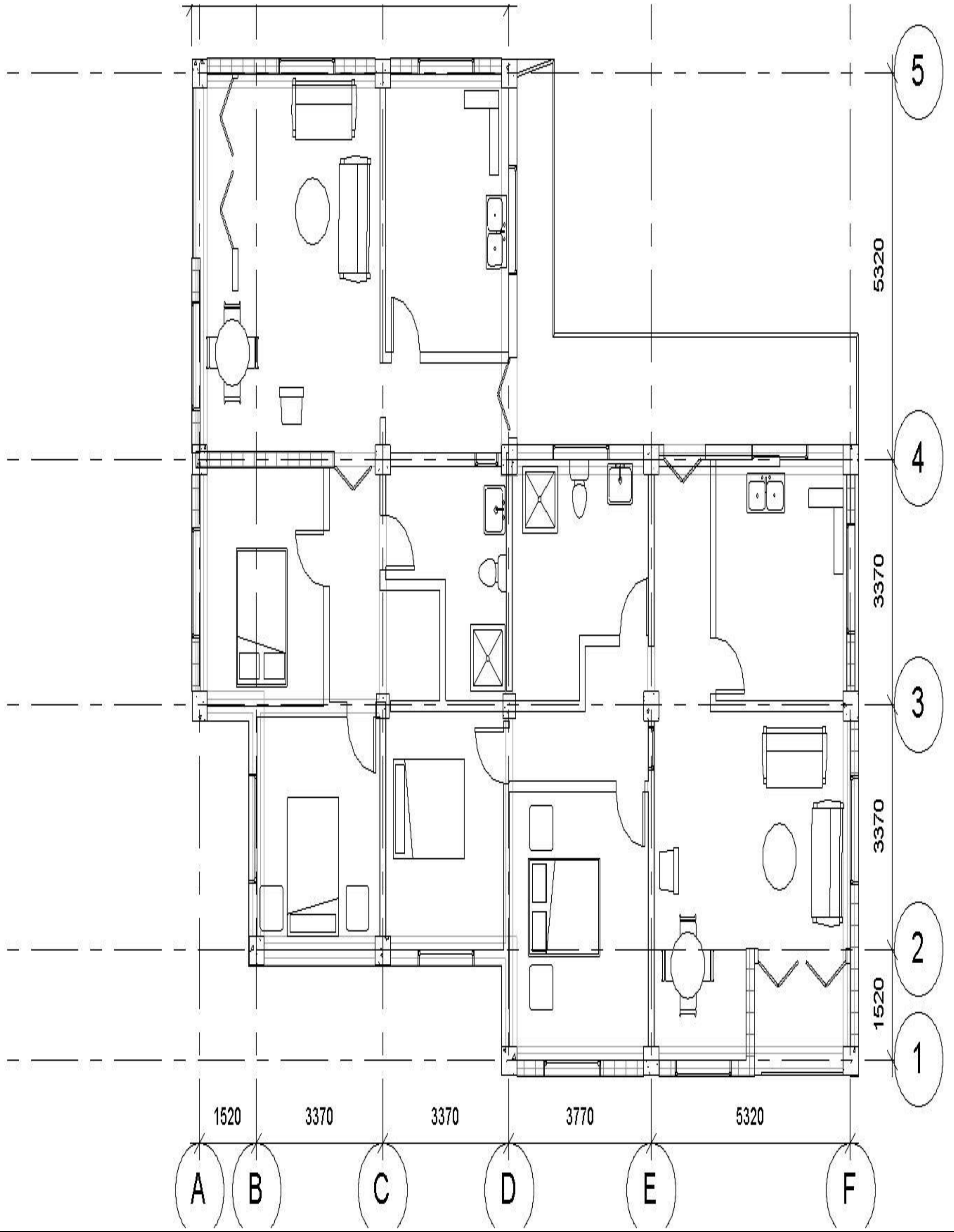


Figure 31: Typical Architectural Floor Plan in Revit Architecture (1st-4th floor)

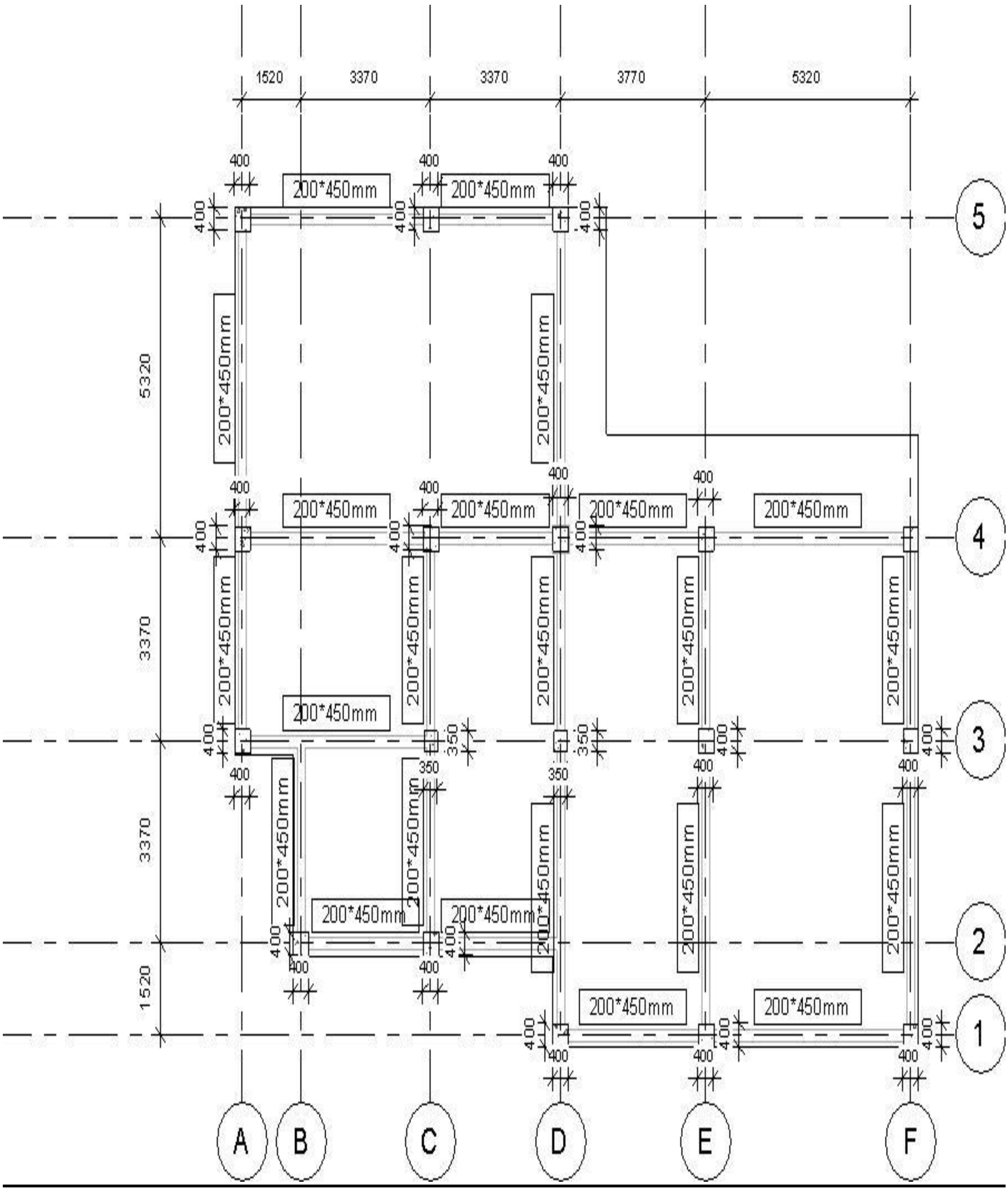


Figure32: Typical structural Floor Plan in Revit Structure (1st-4th floor)

- All Floor slabs of this project are designed using coefficient method of design using EBCS-1995
- The method of Design used is ULTIMATE Limit State Design Method.
- Codes used areEBCS1-8 1995 and BS 8110.
- Excel 2010 SAP 2000, Revit Architecture 2011; Revit Structure2011 soft wares are used.
- The Architectural Drawings from Revit Architecture and Structural outputs from Revit structure are enclosed in appendix A.

5.4.1Method of Design: ULTIMATE Limit State Design Method

<u>Codes Used EBCS1-8 1995 and BS 8110</u>

Material Data:

Concrete Grade c-25

Fck=20Mpa

Fcd=11.33 Mpa

Fctk=1.55 Mpa

ϒc=25kKN/m3

Partial factor of safety for materials ϒc=1.50 ϒs=1.15

Steel Strength

For dia<6mm Fyk=410Mpa(Grade 60)

Fyd=356.52Mpa

fyk=300Mpa

fyd=260.87 Mpa

5.4.2. Analysis and design of Typical Floor slab (1-4th floor)

<u>Depth determination</u>

Thickness of slab that attains serviceability limit is D= 18cm

Dead load:

i) Own weight of slab=0.18*25Kpa=4.5 Kpa

ii) Superimposed load

Average 4cm cement screed=0.04*23=0.92 Kpa

2cm marble tile =0.02*27kpa=0.54 kpa

2cm ceiling plaster=0.02*23=0.46 Kpa,   Subtotal=1.92 Kpa

Table 2: Slab Analysis Results from coefficient method

Slab Panel	Mxs (KNm)	Mys(KNm)	Mxf(KNm)	Myf(KNm)
S1	24.1	27.37	29.24	17.925
S2	24.1	9.35	7.51	5.23
S3	9.35	22.98	10.55	6.02
S4	9.42	7.97	5.05	5.05
S5	25.17	-	9.08	5.25
S6	25.17	-	28.61	17.5
S7	27.37	-	-	-
S8	14.3	-	-	-

Table3: Slab Design Results from coefficient method

Slab Panel	Bar ϕ and C/C spacing (xs)	Bar ϕ and C/C spacing (ys)	Bar ϕ and C/C spacing (yf)Mxf	Bar ϕ and C/C spacing (yf)
S1	Φ 10mm c/c 170	Φ 10mm c/c 140	Φ 10mm c/c 130	Φ 10mm c/c 200
S2	Φ 10mm c/c 170	Φ 10mm c/c 200	Φ 10mm c/c 200	Φ 10mm c/c 200
S3	Φ 10mm c/c 200	Φ 10mm c/c 170	Φ 10mm c/c 200	Φ 10mm c/c 200
S4	Φ 12mm c/c 200	Φ 12mm c/c 200	Φ 10mm c/c 200	Φ 10mm c/c 200
S5	Φ 12mm c/c 200	Φ 10mm c/c 200	Φ 10mm c/c 200	Φ 10mm c/c 200
S6	Φ 12mm c/c 200	Φ 10mm c/c 200	Φ 10mm c/c 140	Φ 10mm c/c 200
S7	Φ 10mm c/c 140	Φ 10mm c/c 200	Φ 10mm c/c 200	Φ 10mm c/c 200
S8	Φ 12mm c/c 200	Φ 10mm c/c 200	Φ 10mm c/c 200	Φ 10mm c/c 200

5.4.3. Frame Input and output

The SAP inputs and out puts of structural frame analysis are enclosed in appendix B.

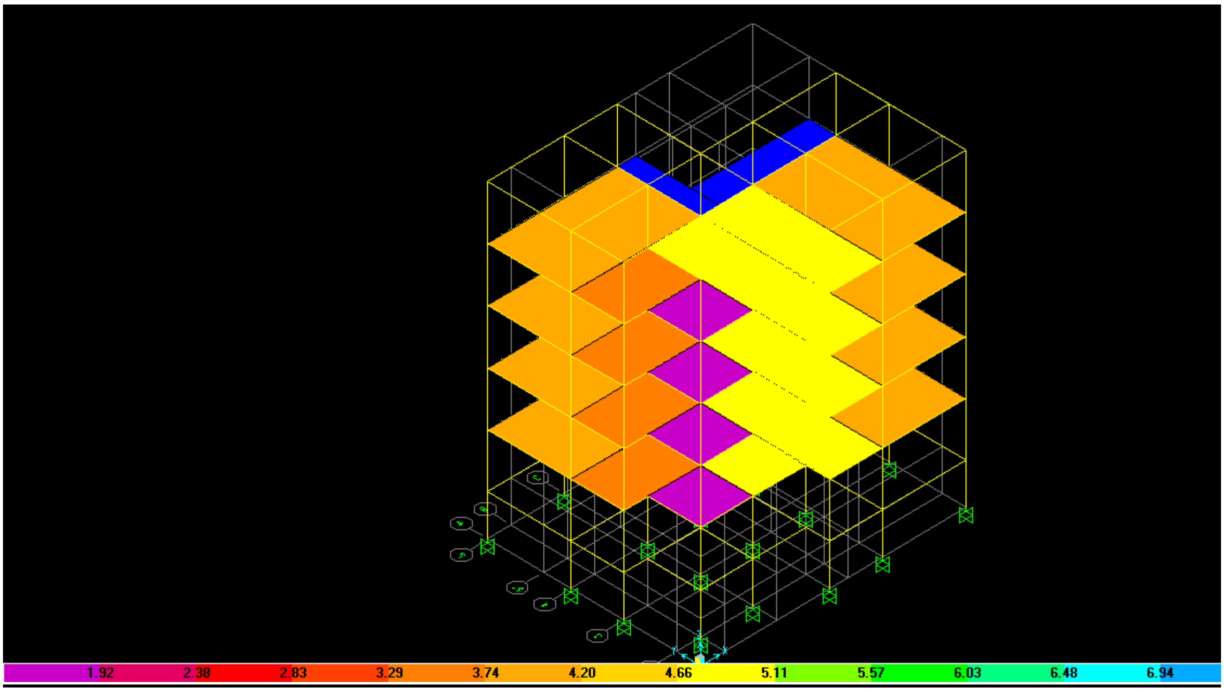


Figure33: The render view of Structural model in SAP 2000

5.4.4 Beam Design

Material Data:

Concrete Grade C-25

Fck=20Mpa

Fcd=11.33 Mpa

Fctk=1.55 Mpa

ϒc=25KN/m3

Steel Strength

Fyk=410Mpa(Grade 60)

Fyd=356.52Mpa

Partial factor of safety for materials ϒc=1.50 ϒs=1.15

- Sections used for beam design is 200mmx450mm
- Structural Analysis is done using SAP 2000

5.4.5 Column Design

Material Data:

Concrete Grade:C-30

Fck=24Mpa

Fcd=13.60 Mpa

Fctd=1.16 Mpa

ϒc=30 kKN/m3

Partial factor of safety for
materials ϒc=1.50
ϒs=1.15

Steel Strength

Fyk=410Mpa(Grade 60)

Fyd=356.52Mpa

ρmax =0.08 ρmin =0.008

- Sections used for column design are 450mmx450mm, 400mmx400mm, 350mmx350mm, 300mmx300mm.
- Column Design Results from SAP 2000 and EBCS 1995 Column Longitudinal (Main) bar reinforcement are shown in table 12 below.

Table 4: Column Design Results from SAP 2000 and EBCS 1995

Column Longitudinal (Main) bar reinforcement

Column	Foundation	Section(mm2)	GroundFloor	Section(mm2)	First Floor(mm2)	Section(mm2)	Second Floor	Section(mm2)	Third loor	Section(mm2)	Fourth Floor	Section(mm2)
C1	8Φ16	40*40	8Φ16	40*40	8Φ14	35*35	8Φ14	35*35	6Φ14	30*30	6Φ14	30*30
C2	8Φ16	40*40	8Φ16	40*40	8Φ16	40*40	8Φ14	35*35	8Φ14	35*35	8Φ14	35*35
C3	8Φ14	35*35	8Φ14	35*35	8Φ14	35*35	6Φ14	30*30	6Φ14	30*30	6Φ14	30*30
C4	16Φ20	45*45	14Φ20	45*45	10Φ2	40*40	8Φ14	35*35	8Φ14	30*30	8Φ14	30*30
C5	10Φ20	40*40	10Φ20	40*40	8Φ16	40*40	8Φ14	35*35	8Φ14	30*30	8Φ14	30*30
C6	12Φ20	40*40	12Φ20	40*40	12Φ20	35*35	10Φ16	35*35	10Φ16	35*35	10Φ16	35*35
C7	8Φ16	40*40	8Φ16	40*40	8Φ16	35*35	8Φ16	35*35	8Φ16	30*30	8Φ16	30*30

5.4.6. Foundation Design

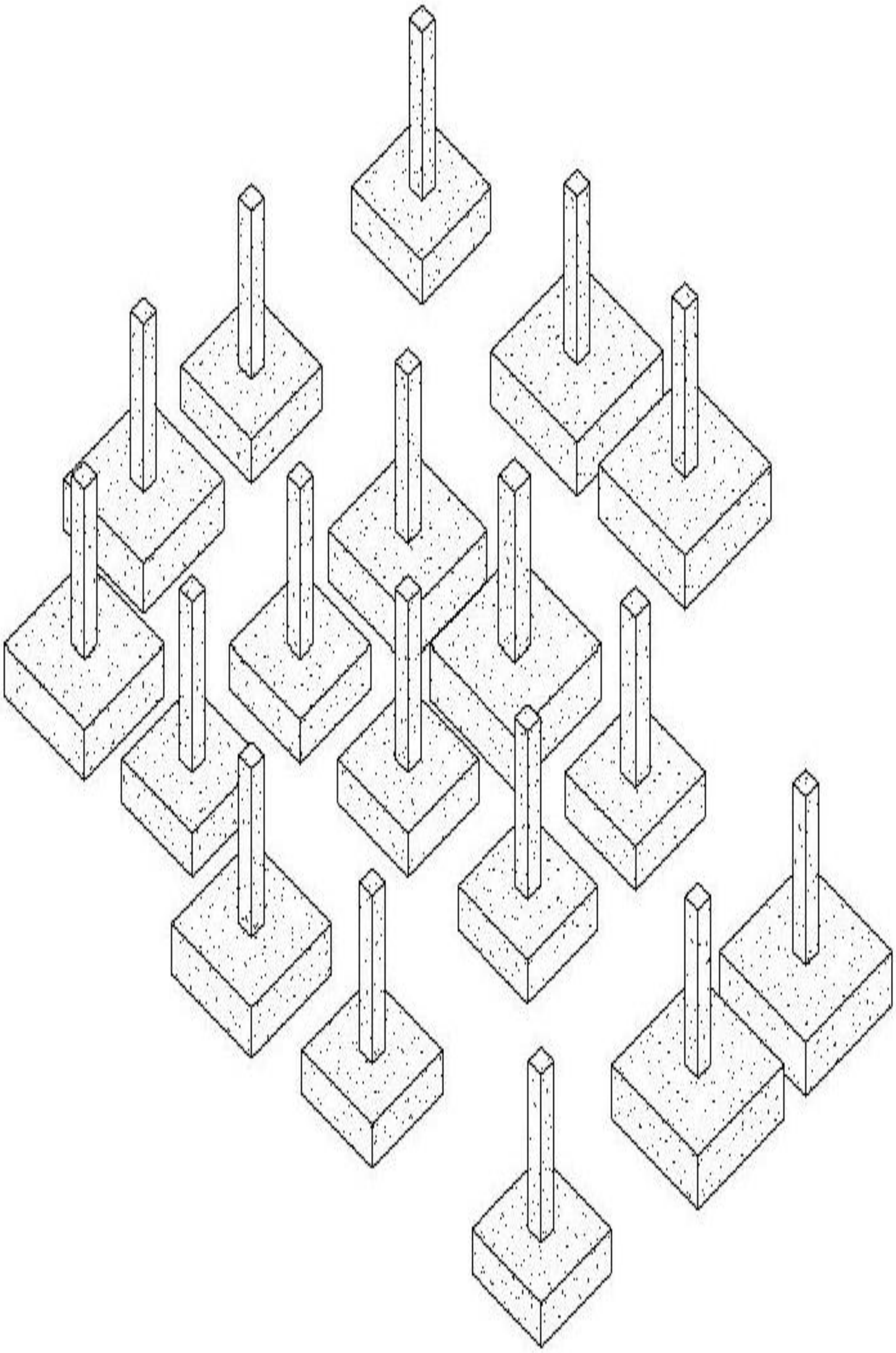


Figure 34: The render view of Foundation footings in Revit Structure

Design of Isolated Footing

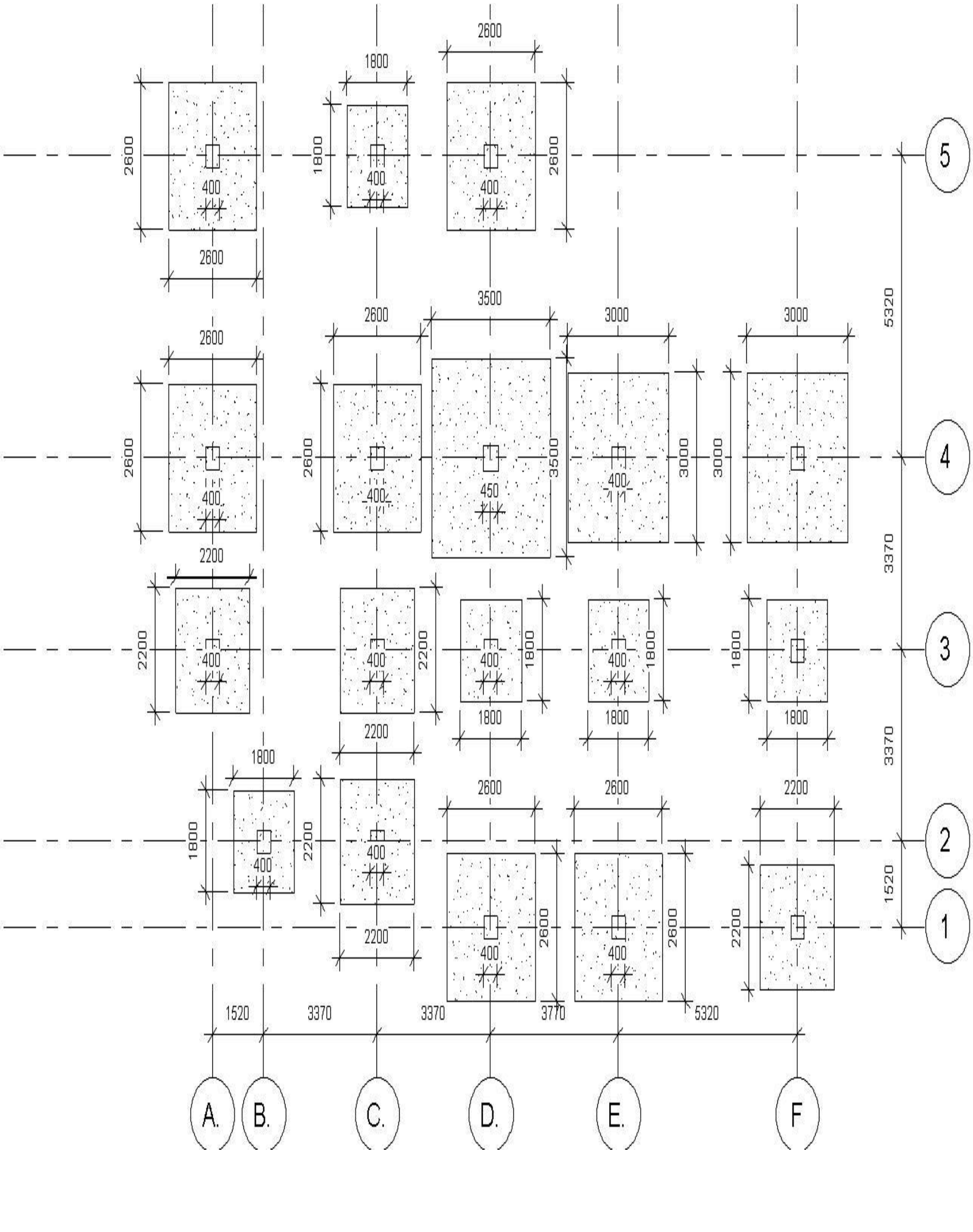


Figure 35: Foundation layout plan using Revit Structure

An isolated footing is a footing that carries a single column. The function of an isolated footing is to spread the column load laterally to the soil so that the stress intensity is reduced to a value that the soil can safely carry.

The approximate contact pressure under a given symmetrical foundation can be obtained from the flexural formula.

$$\sigma_{\substack{max \\ min}} = \frac{P}{BL}\left(1 \pm \frac{6e_x}{L} \pm \frac{6e_y}{L}\right)$$

$$Where\!: \; e_x = \frac{M_y}{P}; \quad e_y = \frac{M_x}{P}$$

The thickness of a given footing that determined by checking the thickness needed for punching shear criteria and wide beam shear criteria. The greater of the two governs the depth of the footing.

Check for Punching Shear

$$Acting\ punching\ shear\!: V_a = \ \sigma_{ave}\left(ab - (\grave{a} + d)\left(\grave{b} + d\right)\right)$$

$$Resisting\ punching\ shear\!: V_r = \upsilon_{up} \times U \times d$$

$$where\ U\ is\ the\ perimeter\ of\ the\ footing\ and \upsilon_{up}\ is\ given\ by\ the\ formula\!:$$

$$\upsilon_{up} = 0.5 f_{ctd} \times (1 + 50\rho_e)$$

$f_{cu} = 25MPa$: fctk=.21*(fck)^(2/3)=1.547

$$f_{ctd} = {}^{fctk}/_{1.5} = {}^{1.547}/_{1.5} = 1.0315MPa$$

fcd = 0.68fcu/**γ**c=11.33

$$f_{yk} = 300MPa \ : \ f_{yd} = 356.52KPa$$

$fbd = 2fctd$=2.34KPa, $\rho_{min} = 0.002$

$$\upsilon_{up} = 0.5 \times 1.17 \times (1 + 50 \times 0.0017) = 634.7MPa$$

Check for Wide Beam Shear

$$Acting\ wide\ beam\ Shear\!: \ V_{wa} = \sigma_{ave}\left(a \times (\frac{b - \grave{b}}{2} - d)\right)$$

$Resisting\ wide\ beam\ shear: V_{wr} = \upsilon_{uw} \times a \times d$

$\upsilon_{up} = 0.3 f_{ctd} \times (1 + 50\rho_e),$

$\upsilon_{up} = 0.3 \times 1.17 \times (1 + 50 \times 0.0017) = 381 KPa$

Design for flexure

$$M_{max} = \frac{\sigma_{ave}}{2}\left[\frac{a - \grave{a}}{2}\right]^2 \times b \ \ [KNm]$$

$K_m = \sqrt{\frac{M}{bd^2}}$: K_s is found from general design table using K_m,$A_s = K_s \frac{M}{d}$: $S = \frac{a_s b}{A_s}$

Table5: Footings and their super structural loadings

Foundation	Axial Load (KN)	Foundation group	Mx (KN.m)	My (KN.m)
3-A	994.25	F2	-2.1713	7.3307
4-A	1866.94	F3	-6.7728	10.5383
5-A	1514.50	F3	10.4032	7.2672
2-B	585.67	F1	-2.9683	3.2489
2-C	1267.17	F2	-3.1164	3.5224
3-C	1185.30	F2	-0.4594	-3.1599
4-C	1711.99	F3	-4.117	-6.4505
5-C	645.69	F1	11.8347	-3.2909
1-D	1546.43	F3	-8.1464	1.3655
3-D	855.31	F1	2.7029	-0.9492
4-D	3818.14	F5	-20.4542	29.175
5-D	2083.86	F3	16.278	12.8411
1-E	2170.05	F3	-9.1917	5.2695
3-E	757.47	F1	3.9716	2.9977
4-E	2766.95	F4	-6.8908	-8.4094
1-F	1456.51	F2	-5.195	-7.7529
3-F	542.36	F1	4.1338	-8.0761
4-F	2585.57	F4	-42.1757	-8.2199

From SAP output we found reaction at the base of the building used for foundation design

- Using sap analysis output we group our footing based on their axial load. Accordingly our SAP output/Using Combination Serviceability output Axial Load, Foundation Group and Moments Mx&My given in tables below.

Table 6: Foundation Group

Axial load range	Foundation group
500KN-900KN	F1
901KN-1500 KN	F2
1501KN-2200KN	F3
2201KN-2800KN	F4

Then, loads are grouped in 4 groups .Then 4 isolated footing groups, and an additional one footing F5 arranged

Type of foundation **Isolated Footings**

Allowable bearing capacity 280Kpa

Unit weight of back fill soil 18KN/m3

Depth of Foundation: 2.5m

Depth of fill 1.75m

Reduction factor of design loads to working loads: 0.71

Material data

Reinforcement bars fyk=410Mpa, fyd=140/1.15=356.52 Mpa

Concrete grade C-25 fctk=20Mpa fcd=11.33 Mpa

fctd=1.04Mpa

Table7: Footing Design Result

Footing	UnfactoredLoad(KNm)	Mx (KNm)	My (KNm)	No	Reinforcement in X-direction	Reinforcement in Y-direction
F1	900	2.7029	-0.9492	5	Φ12c/c120mm	Φ12c/c120mm
F2	1500	-5.195	-7.7529	4	Φ14c/c110mm	Φ14c/c110mm
F3	2200	-9.1917	5.2695	6	Φ14c/c100mm	Φ14c/c100mm
F4	2800	-6.8908	-8.4094	2	Φ14c/c090mm	Φ14c/c090mm
F5	3818	-20.454	29.175	1	Φ16c/c090mm	Φ16c/c090mm

Chapter 6 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The aim of this study is to assess the potential applicability of BIM in the construction industry of Ethiopia –the case of Dire Dawa public project. To reach this aim determining the common construction problems, identifying problems that BIM could solve and gauging the perception of stakeholders (Consultants and Contractors) of the public projects towards BIM was studied. Finally recommendable points to the successful implementation BIM in the projects were put.

Dire Dawa public projects Consultant side professionals and Contractor side professionals are the data source for this study. The study sought the views of consultants, and contractors on the common problems that are in Dire Dawa public construction projects. Changing demands of clients, design error leading to rework, Design revision by consultants/designer, Education and experience of project staff, Poor project planning, scheduling, Wrong time estimate of project period, Delay in progress payments for completed works, Incomplete and inadequate details in drawings, Preparing Incomplete/un detailed BOQ, Poor coordination & communication with other parties, Inadequate delivery of materials are construction problems in Dire Dawa public construction projects.

From the solutions of Problems that BIM offers, Construction documents are generated completely automatic when using a building information model, significantly reducing the time required for detailing. It also reduces the need to make extensive checks, helping prevent errors in the documentation that can affect the construction.

To conclude, BIM technology has a great potential to solve many problems that are faced in all stages of construction projects .Using BIM in construction projects, increases client satisfaction, enables to finish the project within budget, detects collisions, improves communication between parties, provides better understanding of project due to visualization and provides faster and more accurate quantity takeoff. However, in order to apply this new technology, necessary software must be bought and installed and staff should be trained to learn this BIM software. Eventually Construction Firms' can tap the potential benefits of BIM.

The case study on G+4 Apartment Building located in Dire Dawa demonstrated in this paper shows The visualization power of BIM, Coordination between Architectural and structural discipline, time conservative in design, checks interferences, checking off Any mismatching sections, easier way to prepare material take offs. It also presents how the connection between the BIM software and the structural analysis software works. The continuous process of creating structural model in SAP 2000 from a design previously done in Revit Architecture, and the ability to easy make changes and keep track of any alterations made throughout the model are clear demonstration of the benefits of BIM.

The identified construction problems in the projects with the concepts in literature contribute to clearly understand the potential applicability of BIM, especially for designers and contractors. Along with the investigation of construction problems in Dire Dawa public projects, perception of professional's perceptions towards BIM is also investigated, and lack of awareness of Professionals towards BIM is identified.

6.2Recommendations for BIM applications

Executing BIM at firms is big decision, and to make it successful, AEC firms need to understand what change this new process brings and how they should prepare for it. The following strategies are deduced from the research to help make a successful transition from the current 2D-CAD dependent to a BIM based projects.

Integration of BIM into the curricula of Academic Institutions

Dire Dawa Administration should assist the construction Firms by arranging BIM training programs for construction Firms. Moreover, government should insist integration of BIM courses in the university undergraduates' syllabus to have a satisfactory number of BIM operators with full and real awareness of BIM to fill the gap in the construction projects.

Mandating BIM in construction projects

Therefore, to accelerate this process, the government/regional Administration should take the necessary actions to assist the organizations to change smoothly to BIM. The Administration can support construction firms by offering periodical sessions to promote the awareness of the benefits of BIM. In addition, it should raise the Firms' awareness for the challenges that Firms may face and the best way to respond to these challenges during the journey to change to BIM. These sessions should be offered by specialized BIM institutes; all these sessions should be under the support of the Administration.

Choosing the Correct Software

Good strategies fail due to choosing an improper tool. The firms' potential can be improved by using the correct software, and the capabilities can be reduced if the company invests in a software solution which does not serve its BIM needs. Instead of adapting workflows to suit the technology, firms should look for software that allows them to enhance their current workflows. Migrating information production from one platform to another requires a considerable amount of effort, so the most common and basic practice is to look for BIM solutions for the CAD software they are already using rather than investing in a completely new product.

Choosing and Training the Correct Team

Initial stages of BIM implementation are associated with disrupted and low productivity as the transitioning team is trying to learn the new system. Over the period, productivity increases back and rises beyond the point experienced with CAD system, as the new technology takes hold. Construction firms should pay close attention when choosing the transition team. The team should have individuals who are agile, quick learners; who understand the organization's goal; and who will act as a preceptor for BIM. BIM's parametric approach to modeling is the essence of architectural and structural design, so it is advisable to include the organization's best architect and designer on the transition team instead of draftsman.

Pilot projects

Moreover from the results of the interview I suggest that, to minimize uncertainties correlated with the change to adopt BIM, implementation of BIM better be tried internally first in a pilot project. Hence the funding for such project will not be huge and the resistance to change can be managed by selecting the flexible staff, and the overall success to the pilot project experiences can be generalized to the entire construction Firms. Moreover, close monitoring for the pilot project, in addition to careful studying for the lessons learned from other experiences within other world countries will highly assist the soft and swift transition to BIM. Accordingly, the top managements' support will be gained. Therefore, further improvement could be achieved especially after avoiding the Awareness and exposure gaps to mandating BIM on the entire construction projects.

In order to suggest strategies for increased knowledge of BIM towards improving productivity and increased efficiency in Dire Dawa construction projects, the research seeks to recommend the following shortly:

- Make advantage of BIM experts to teach and prepare BIM training manuals for all stake holders of Dire Dawa public projects.
- Proper awareness should be instilled in the construction industry to gain better understanding and confidence. This initial step is crucial and it requires a great degree of commitment from

government, professional institutions and associations to raise awareness about BIM application and its benefits.

- To integrate BIM in Dire Dawa public projects along with the existing process to increase Awareness of Professionals towards BIM.
- The full integration of BIM into the curricula of Academic Institutions as a necessary step towards increased knowledge of BIM. This will help Graduates to have knowledge of the concept & implementation of BIM in construction projects earlier.
- To implement BIM first in a pilot project as a trial projects, i.e. small or medium size project.
- Adoption of BIM by Dire Dawa Public Construction projects to defeat its inefficiency problems.

6.3. Suggestions for further research

Several interesting subjects were encountered during the process of producing this master thesis. These have however not been within the scope and purpose of this study and are therefore suggested as subjects for further research. Subjects that require further investigation:

- How organizational culture affects the ability to implement new ways of working.
- Future studies can be carried out on projects in Ethiopia involving the governmental and private sectors. So that an approach can be recommended to assist construction players in using this technology for construction projects all over Ethiopia.
- Conducting BIM pilot projects where collaboration approach has worked well and specify what good collaboration looks like when it is happening.
- Conducting BIM pilot projects to quantity and qualified the excellence of BIM over traditional 2D based processes.

REFERENCES

Abdul-Rahman, H., Berawi, M., Berawi, A., Mohamed, O., Othman, M., &Yahya, I. (2006).Delay mitigation in the Malaysian construction industry.*Journal of construction engineering and management*.

AfDB, (2011), *The Africa Infrastructure Development Index*, Economic Brief, 1(1), African Development Bank, Tunis.

Al-Momani, A. H. (2000). Construction delay: a quantitative analysis. *International Journal of project management*, *18*(1), 51-59.

Ashcraft, H. (2007). *Building Information Modelling – A Framework for Collaboration, Construction Lawyer*, vol. 28, Number 3, accessed: February 2010, http://hbmvr.com/docs/articles/bim_building_information_modeling_a_framework_for_collaboration

Ashcraft, H. W. (2006). Sexy, Young Technology Seeks Stable Project Delivery Method for Lasting Relationship...BIM. San Francisco, CA: Infrastructure Blog, 5-7.

Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering 11*(3)

Batcheler, I. H. a. B. (2007).Building Information Modeling Better, Worse or Just Different. http://www.newforma.com/building-information-modeling-better-worseor-just-different

Bazjanac, Vladimir. (2008). Impact of the U.S. National Building Information Model Standard (NBIMS) on Building Energy Performance Simulation. Lawrence Berkeley National Laboratory: Lawrence Berkeley National Laboratory: http://escholarship.org/uc/item/3v95d7xp

Becerik-Gerber, B., & Rice, S. (2010). The perceived value of building information modeling in the US building industry. *Journal of IT in Construction, 15*(2), 185-201.

CAD Services. (2012, July 30). *BIM Implementation – Where does India Stand?*: http://cadservicesindia.wordpress.com/2012/07/30/bim-implementation-where-does-india-stand/

Caldas, C. H., Kim, J.-Y., Haas, C. T., Goodrum, P. M., & Zhang, D. (2014).Method to Assess the Level of Implementation of Productivity Practices on Industrial Projects.*Journal of construction engineering and management, 141*(1).

Chatterjee, N. (2013). *Trimble launches new technologies for Indian construction industry* http://www.tekla.com/in/about/news/trimble-launches-new-technologiesIndian-construction-industry.

CHIEN, K.-F., WU, Z.-H.& HUANG, S.-C. 2014. Identifying and Assessing Critical Risk Factors for BIM Projects: Empirical Study. *Automation in Construction,* 45**,** 1-15.

CIMP (2007).Construction Industry Master Plan 2006 – 2015 (CIMP 2006 – 2015), Construction Industry Development Board Malaysia (CIDB), December 2007, Kuala Lumpur.

Creswell, J. W. (2013). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches* (Vol. 3rd Edition). SAGE Publications Ltd. 1 Oliver's Yard, 55 City Road,

DenamoAddissie (2016), BIM for Infrastructure Sustainability in Developing Countries: the case of Ethiopia, EiABC, Addis Ababa University

Duval, Y. (2005). Primary Data collection Methods: Survey Design. ART Net Capacity Building Workshop on Trade Research.

Eastman, C. (1999). BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors,Johnwiley& sons,Inc.,Hoboken,New Jersey

Eastman, C., Teicholz, P., Sacks, R., & Liston, K.,(2008). *BIM handbook : a guide to building information modelling for owner, managers, designers, engineers, and contractors*. New Jersey: John Wiley and Sons, Inc.

Eastman, C., Teicholz, P., Sacks, R., & Liston, K.,(2011). *BIM handbook : a guide to building information modelling for owner, managers, designers, engineers, and contractors*. (2nd ed.) New Jersey: John Wiley and Sons, Inc.

Englander, M. (2012). The interview: Data collection in descriptive phenomenological human scientific research*. *Journal of Phenomenological Psychology, 43*(1), 13-35.

ERA (2009), *Business Process Re-engineering*, Ethiopian Roads Authority, Addis Ababa.

Fellows, R., & Liu, A. (2008). Research methods for construction (3rd ed.) west Sussex: Wiley-Blackwell.

Fortner, B., et al. (2008). "Special Report: Are You Ready for BIM?" Civil Engineering-Reston 78(5): 44-57.

Franklin, J. (2010). *Benefits and Limits of Cloud Computing.* Boulder, CO: AIA.

Geodert,J.D.,and Meadati,P,2008.'Integrating construction process documentation into building information modeling', Journal of construction Engineering and management.

Grilo, A., &Jardim-Goncalves, R. (2010).*Value Proposition on Interoperability of BIM And Collaborative Working Environments*. Automation in Construction. 19 (5), 522–530.(Jiang, 2011).

HARDIN, B. 2009.*BIM and construction management: proven tools, methods, and workflows,* Indianapolis, Ind., Wiley Pub.

HARRIS, B. & ALVES, T. D. C. L. 4D Building Information Modeling and Field Operations: An Exploratory Study. 21st Annual Conference of the Internation Group for Lean Construction, 2013 Fortaleza, Brazil.811-820.

HATTAB, M. A. & HAMZEH, F. Information Flow Comparison Between Traditional and BIM-Based Projects in the Design Phase. 21st Annual Conference of the International Group for Lean Construction, 2013 Fortaleza, Brazil.761-770.

Hergunsel, M. F. (2011). Benefits of Building Information Modeling for Construction Managers and BIM Based Scheduling. Worcester: Worcester Polytechnic Institute.

Hycner, R. H. (1999) Some guidelines for the phenomenological analysis of interview data. In A. Bryman&R. .G. Burgess (Eds.), Qualitative research (Vol. 3, pp. 143-164). London:Sage.

Jaradat, S. (2012).The Architect's Role and Interactions in BIM-enabled Projects, Unpublished PhD Research, School of Construction Management and Engineering, University of Reading, UK.

Kadir M.R.A, Lee W.P., Jaafar M.S., Sapuan S.M. &Ali (2005). Factors affecting construction labour productivity for Malaysian residential projects. *Structural Survey 23* (1), 42-54

Khemlani, L. (2007). Top criteria for BIM solutions: AECbytes survey results. AECbytes Special Report,AECbytes: http://www.aecbytes.com/feature/2007/BIMSurveyReport.html

Laskar, A., &Murty, C. (2004).Challenges before construction industry in India.*Department of Civil Engineering, Indian Institute of Technology, Kanpur (www. iityk. ac. in)*.

Lee, A., & Sexton, M.G. (2007).nDmodelling: industry uptake considerations. *Journal of Construction Innovation 7*(3), 288-302

Lee, A., Marshall-Ponting, A.J., Aouad, G., Wu, S., Koh, I., Fu, C., Cooper, R., Betts, M., Kagioglou, M., & Fischer, M. (2003).*Developing a vision of nD-enabled construction*. Construct IT Report, ISBN: 1-900491-92-3

London EC1Y 1SP, United Kingdom: SAGE Publications, IncFink, A. (1995). The survey kit 1. Thousand Oaks, CA: Sage publications

Long, N. D., Ogunlana, S., Quang, T., & Lam, K. C. (2004). Large construction projects in developing countries: a case study from Vietnam. *International Journal of project management, 22*(7), 553-561.

Marshall-Ponting&Aouad, 2005) Marshall-Ponting, A., &Aouad, G., (2005). An nDmodelling approach to improve communication processes for construction. *Automation in Construction 14*(3), 311-321

McGraw Hill Construction. (2012). *The Business Value of BIM in North America.* Bedford, MA: McGraw Hill Construction

Micheal, S. (2013, November).Building Information Modelling.*National Building Specifications (NBS)*.

National Building Information Modeling Standard, Transforming the Building Supply Chain through Open and Interoperable Information Exchanges, version 1.0 — Part 1 — Overview, Principles and Methodologies; NBIS, 2007

Ofori, G. (1994). Construction industry development: role of technology transfer. *Construction management and economics, 12*(5), 379-392.

Ofori, G. (2000). *Challenges of construction industries in developing countries: Lessons from various countries.* Paper presented at the 2nd International Conference on Construction in Developing Countries: Challenges Facing the Construction Industry in Developing Countries, Gaborone, November.

Ogunlana, S., Lim, J. and Saeed, K. (1998), DESMAN: a dynamic model for managing civilengineering projects, *Computers and Structures*, 67(5) 401 – 419.

Olanrewaju, A. L., & Abdul-Aziz, A.-R. (2015). An Overview of the Construction Industry *Building Maintenance Processes and Practices* (pp. 9-32): Springer.

Patricia A. Adler&Peter Adler - *Constructions of Deviance Social Power, Context, and Interaction* (1905-07-14) [Paperback] Paperback – July 14, 1905.

Rajendran, S., & Clarke, B. (2011).*Safety Benefits and Opportunities*

Shen, Z., &Issa, R.R.A. (2010).*Quantitative Evaluation of the BIM-Assisted Construction Detailed Cost Estimates.* Papers in Construction Management.

Singapore Government. (2013, July 22). *Technology Adoption: Building Information Model (BIM) Fund*. April 6, 2014, from Building and Construction Authority (BCA): http://www.bca.gov.sg/BIM/bimfund.html

Smith D.K &Tardiff M. (2009). *Building information modeling:a strategic implementation guide for architects, engineers, constructors and real estate asset managers*. New Jersey: John Wiley & Sons, Inc

Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. Automation in Construction 18(3): 357-375.

Swarup, P. (2007). Indian construction industry.*New Delhi, Construction Industry DevelopmentCouncil, New Delhi*.

Sweis, G. J., Sweis, R. J., Al-Shboul, M. A., & Al-Dweik, G. A. (2015). The Impact of Information Technology (IT) Adoption on the Quality of Construction Projects: The Case of Jordan. *International Journal of Information Technology Project Management (IJITPM), 6*(3), 26-40.

Sweis, G., Sweis, R., Hammad, A. A., &Shboul, A. (2008). Delays in construction projects: The case of Jordan. *International Journal of project management, 26*(6), 665-674.

UK Government Construction Strategy, from UK Government:https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/61152/Government-Construction-Strategy

VANDEZANDE, J., READ, P. & KRYGIEL, E. 2011.*Mastering Autodesk Revit architecture 2012,* Indianapolis, IN, Wiley.

Vyas, S. (2013). Causes of delay in project construction in developing countries.*Indian journal*

Watson, A (2010) BIM -a driver for change. In: Tizani, W (Ed), "The 13th International Conference on Computing in Civil and Building Engineering", 30 June -2 July 2010, University of Nottingham.

WerkuKoshe, K. N. Jha. Investigating Causes of Construction Delay in Ethiopian Construction Industries.*Journal of Civil, Construction and Environmental Engineering.*Vol. 1, No. 1, 2016, pp. 18-29. doi: 10.11648/j.jccee.20160101.13

Won, J., Lee, G., Dossick, C., &Messner, J. (2013a).Where to focus for successful adoption of building information modeling within organization.*Journal of construction engineering and management, 139*(11), 04013014.

Won, J., Lee, G., Dossick, C., &Messner, J. (2013b).Where to focus for successful adoption of building information modeling within organization.*Journal of construction engineering and management, 139*(11).

Wubishet, J. (2004), *Performances for Public Construction Projects in (Least) Developing Countries**:** Federal Road and Educational Building Projects in Ethiopia, Unpbulished thesis (PhD), Norwegian University of Science and Technology.*

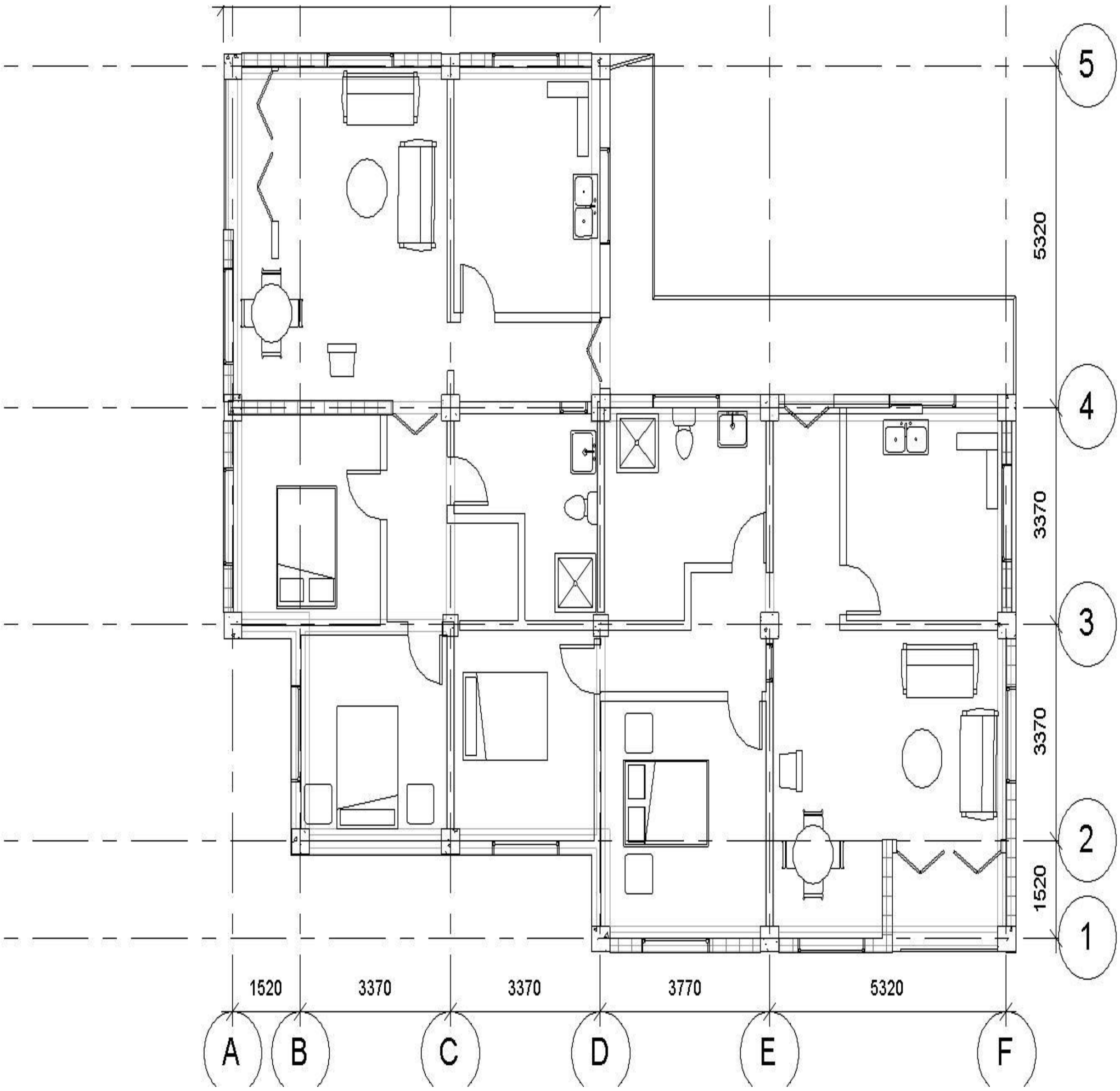
Yoders, J. (2013, November 20). *Collaboration: How Architects and Engineers Can Work Together with BIM in the Cloud*:http://lineshapespace.com/how-architects-and-engineers-can-work-together-with-bim-in-the-cloud

APPENDICES

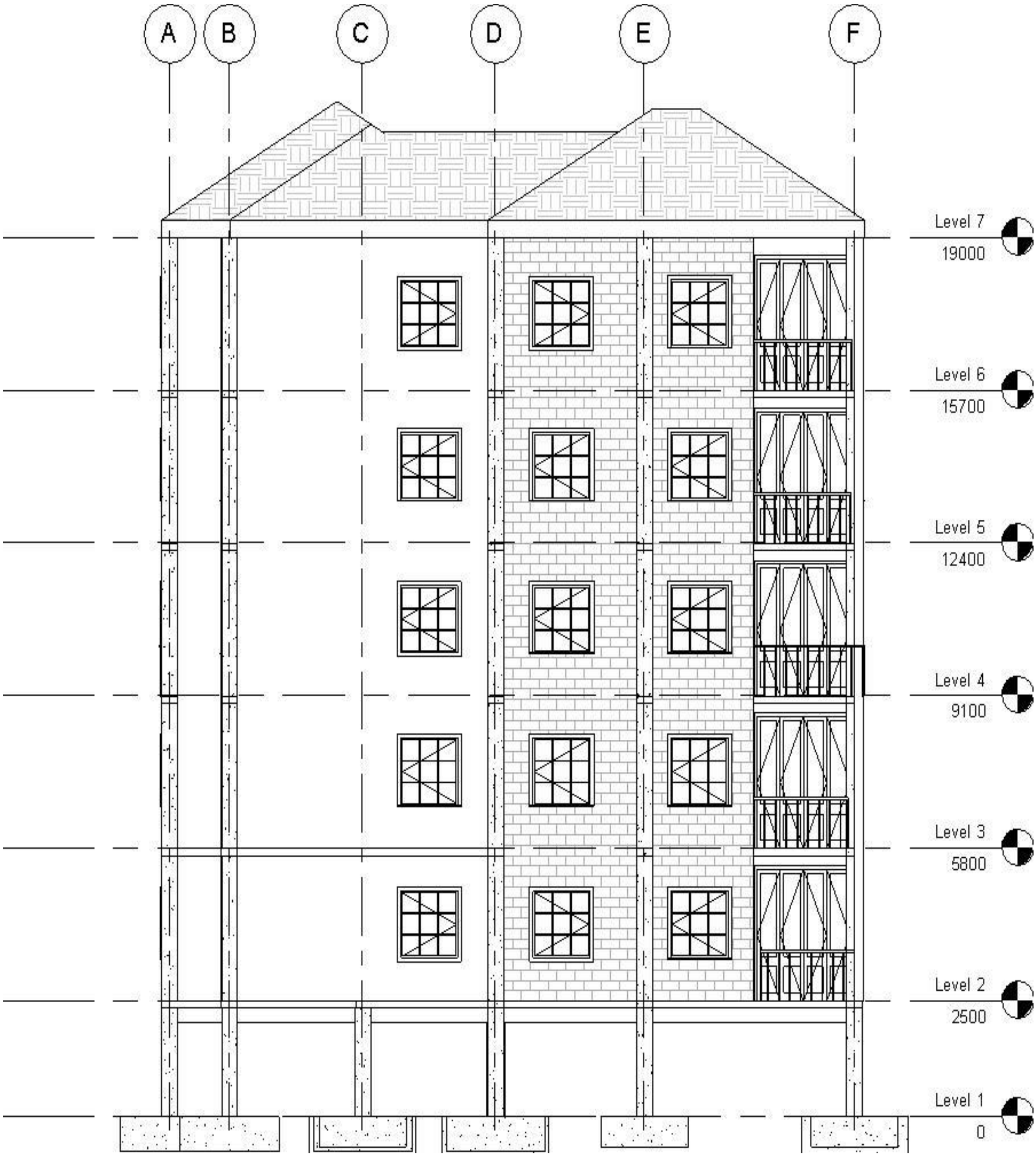
Appendix A: BIM Software (Revit) outputs

Rear –Right (North-East 3D view)

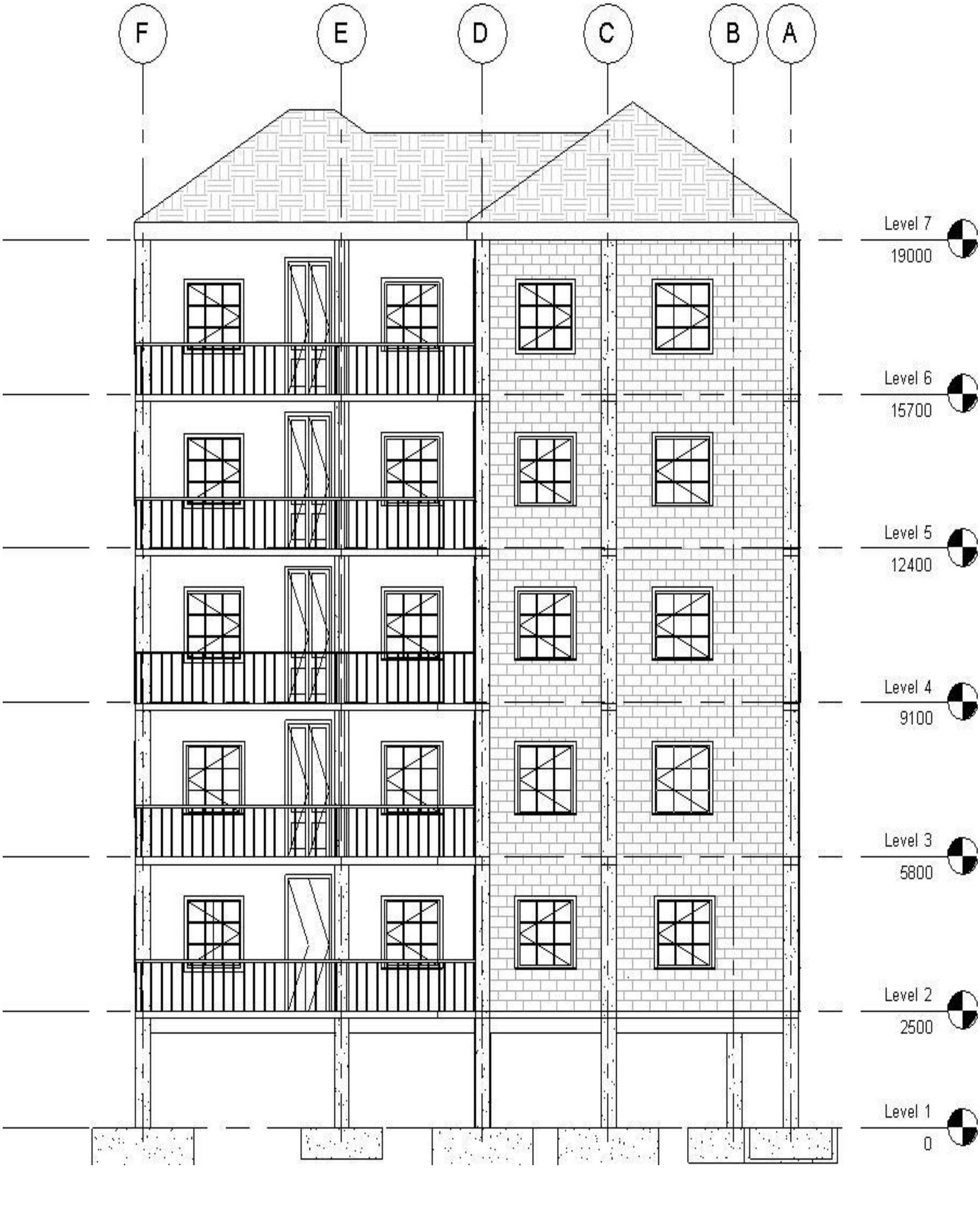
Front –Left (South West 3D view)



Typical Architectural Floor Plan in Revit Architecture (1st-4th floor)

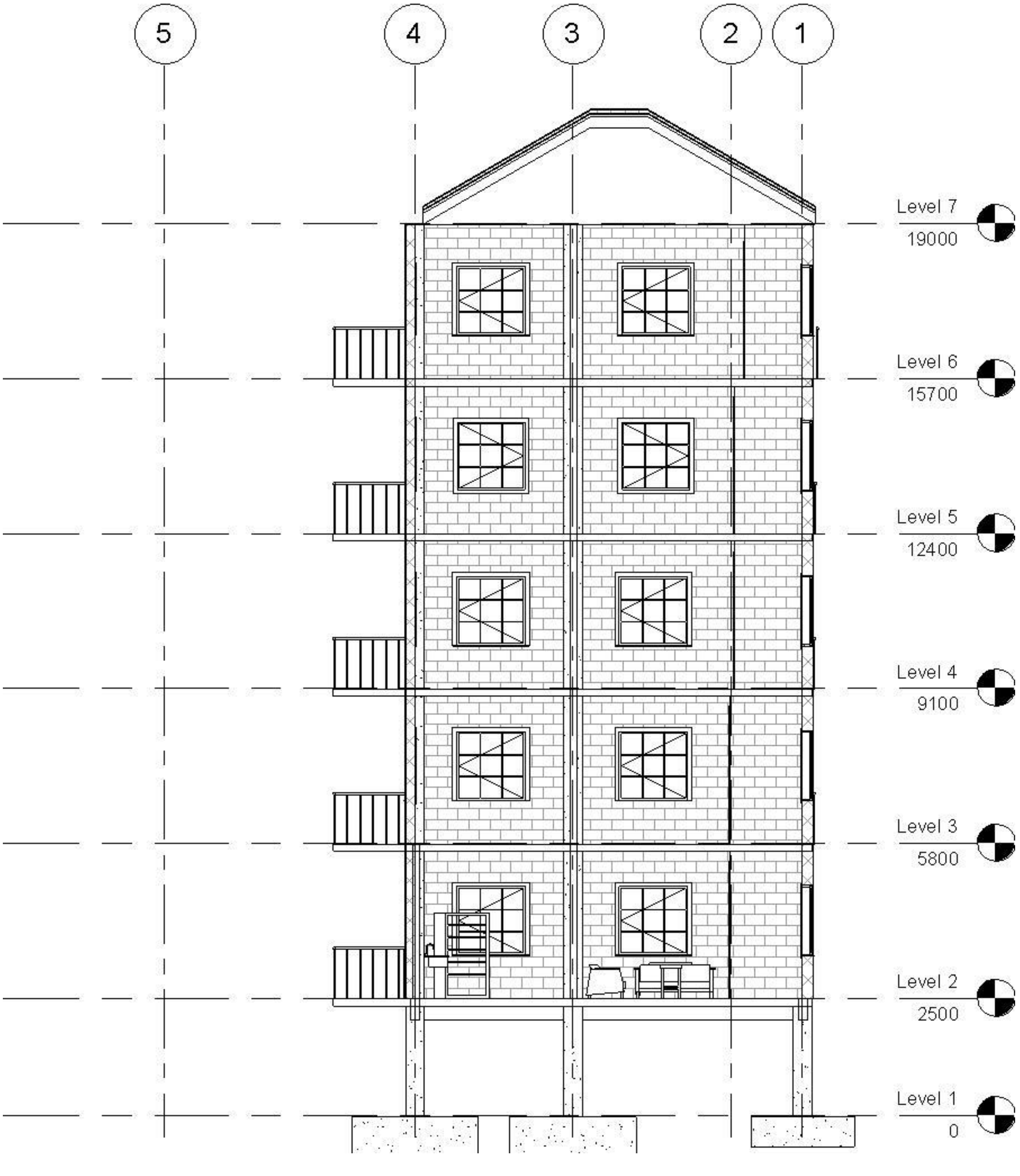


South Elevation view

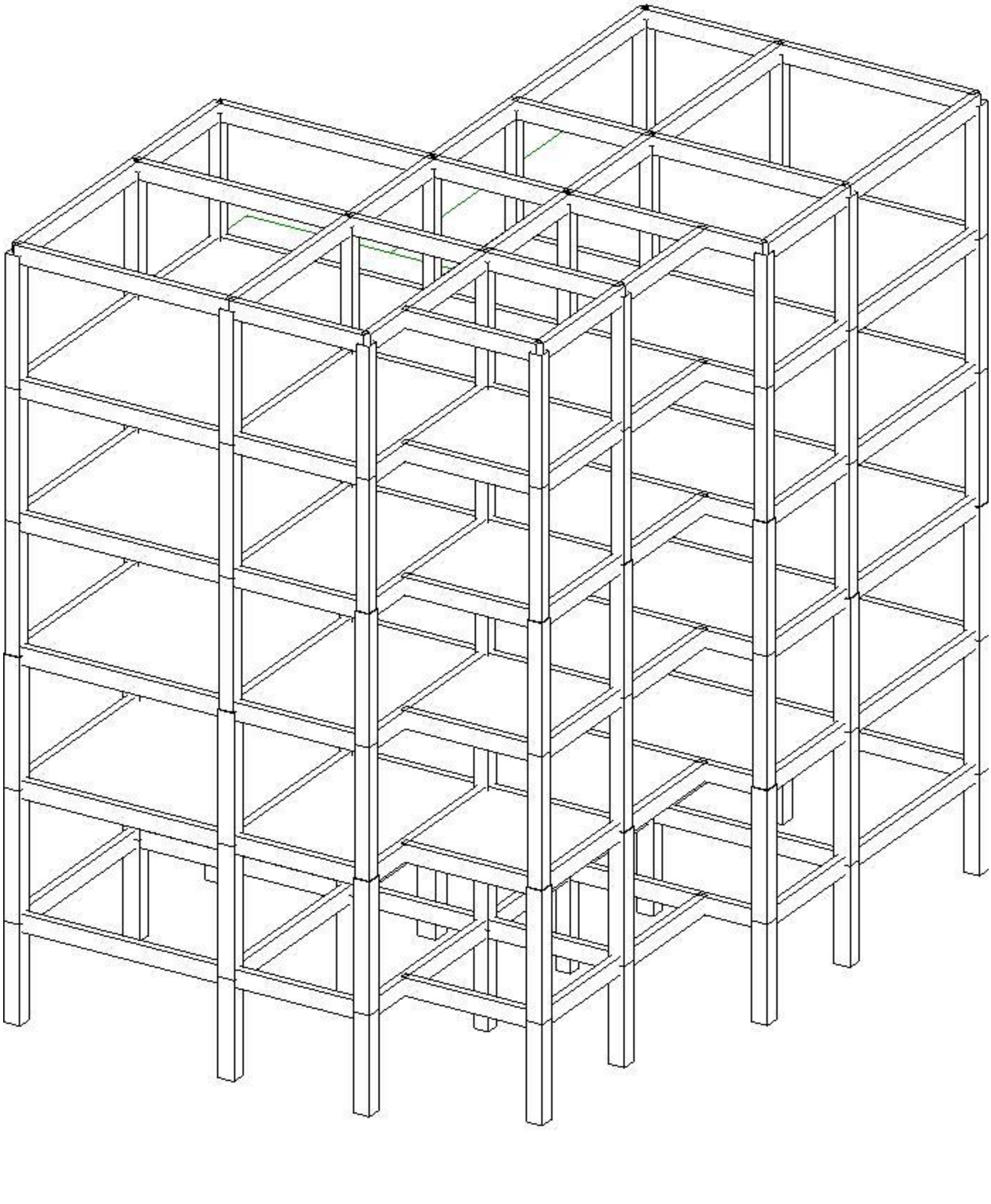


North Elevation view

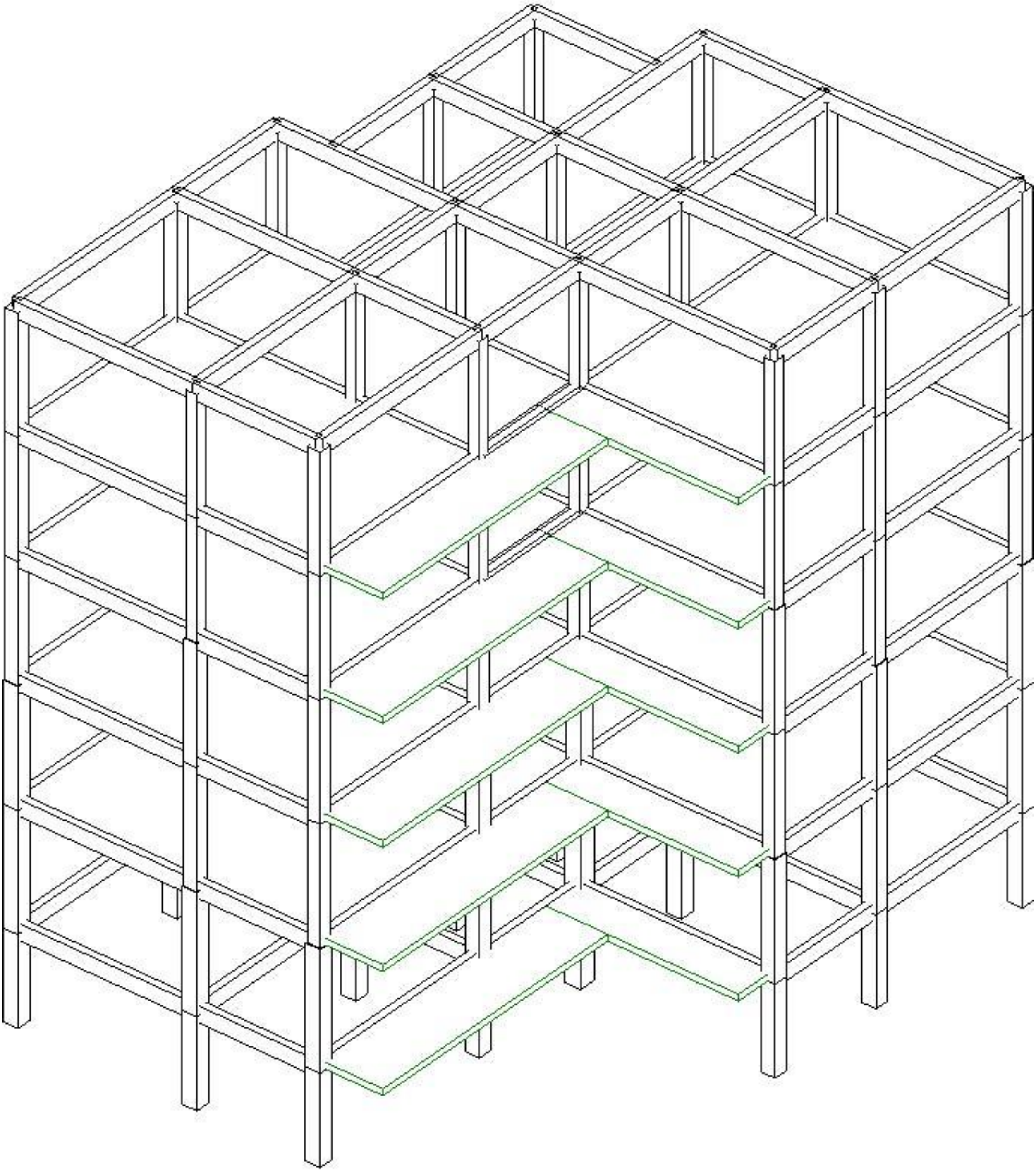
East Elevation View



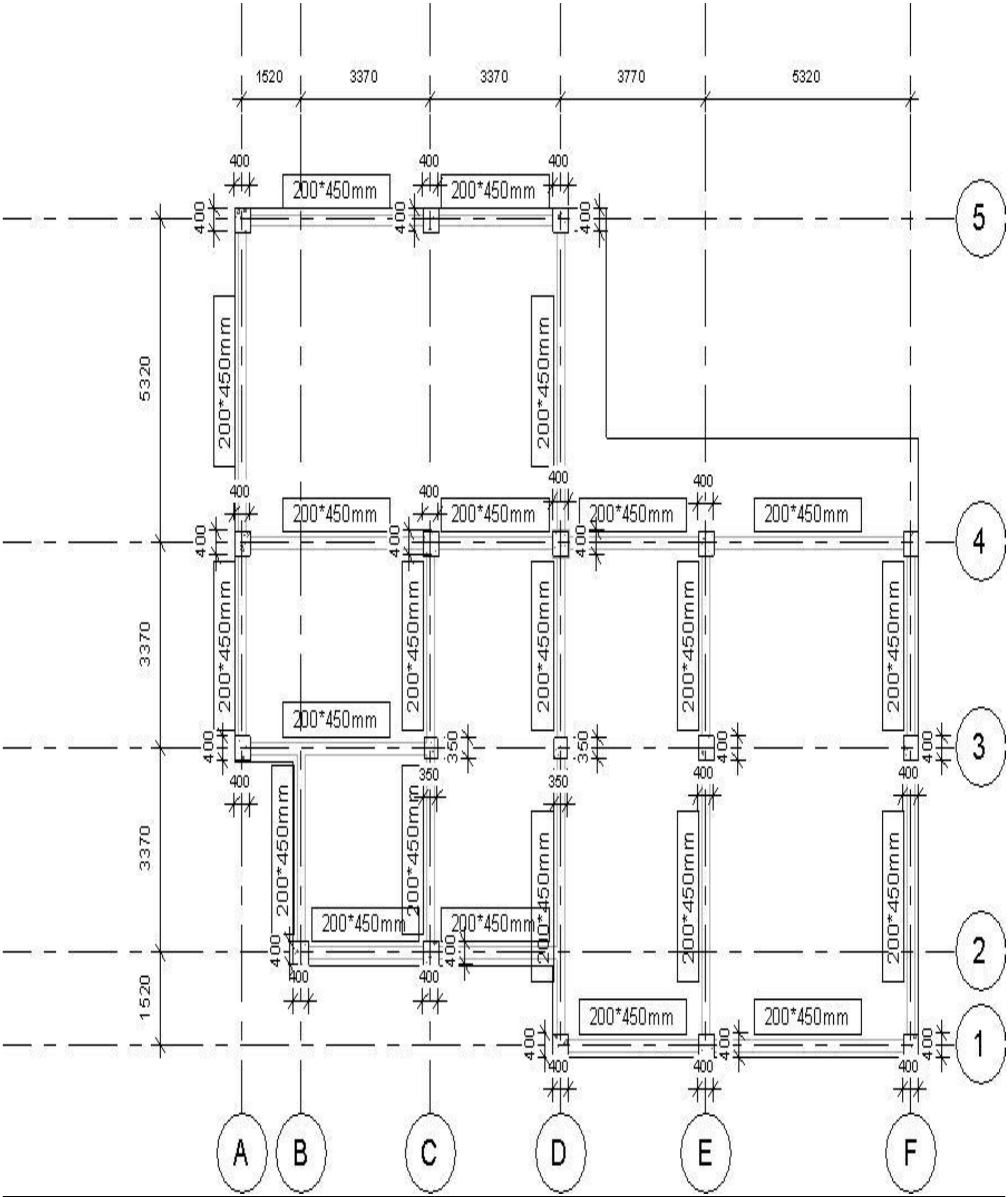
West Elevation view



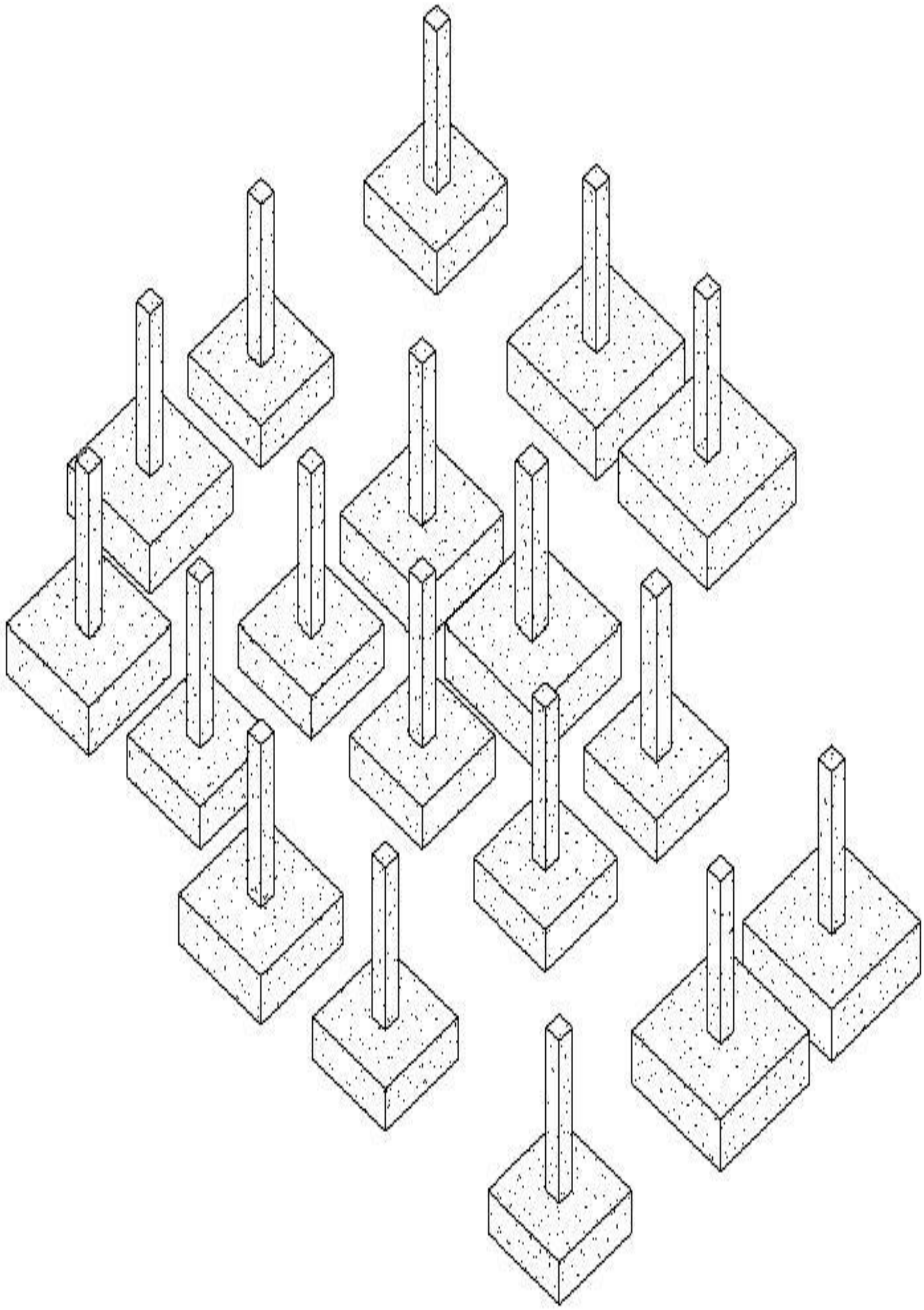
Front-Left structural frame view



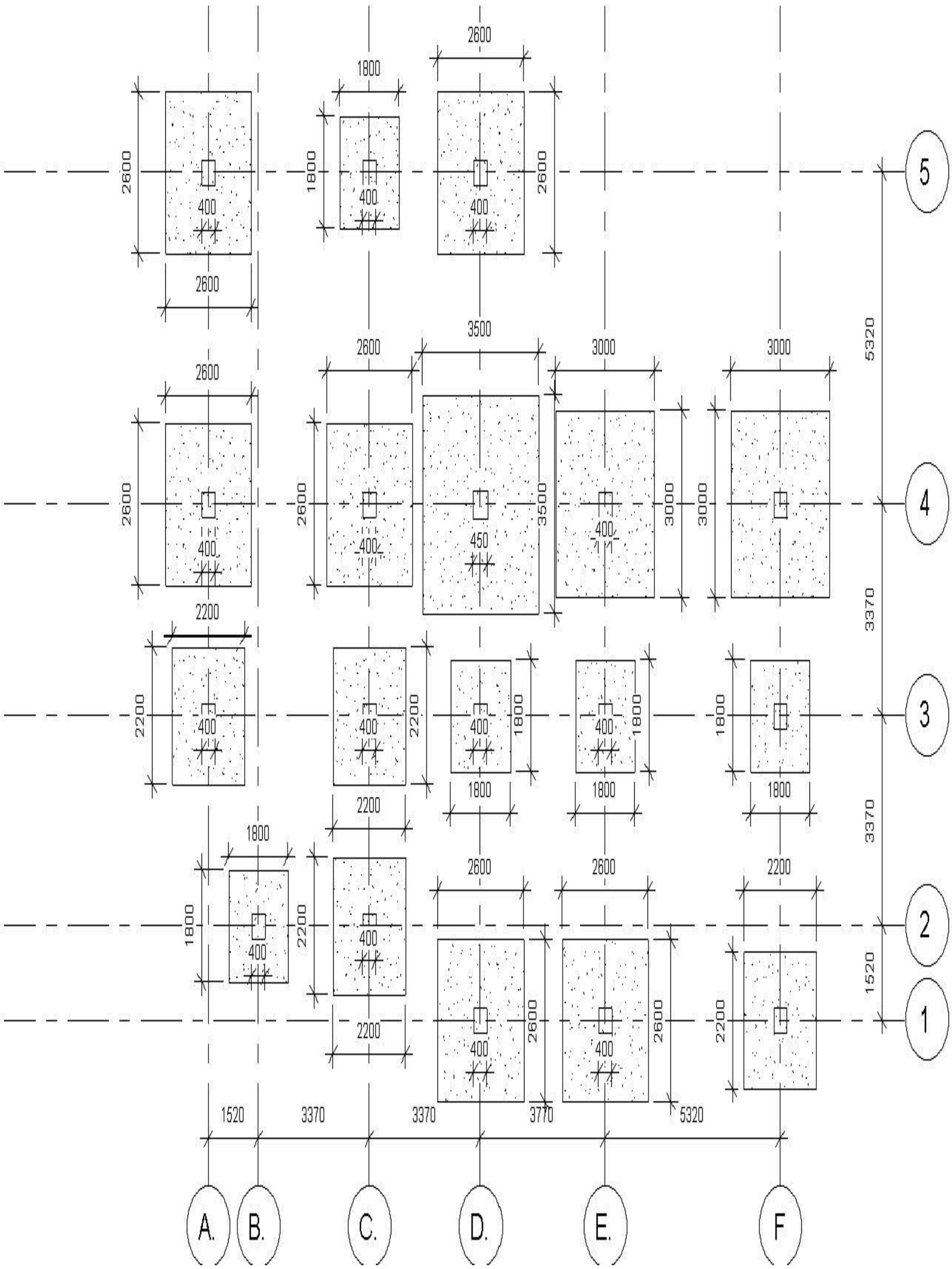
3D Rearright Structural Frame view



Typical Structural Floor Plan in Revit Structure (1st-4th floor)



The 3D view of Foundation footings &Foundation column in Revit Structure



Foundation layout plan using Revit Structure

Appendix B: Interview Questions

Name of professional……………..Company Name ………………………

Consulting/contractor …………..……. Job title………………………

1-General Information

1.1 What is the type of construction firm you work for?

1.2 What is your primary role/duty in your company?

1.3. How many years have you worked in construction field?

1.4 What is the type of construction that your company builds?

2. Construction Problems

2.1 What are the construction problems in your projects?

2.2 What can be the solutions to the problems?

3. General BIM Knowledge and BIM Implementation status

3.1 Have you heard of Building Information Modeling (BIM) solutions and Applications?

- o Yes O No

3.2 How would you describe BIM?

3.3 Have you used BIM solutions and Application in your projects?

3.4 How would you characterize the current knowledge level of BIM in your projects?

- o None O Low O Medium O High O Very high

3.5 Is your organization planning to use BIM in the next 1-2 years?

- o Yes O Not O I don't Know